CREATING INDIVIDUAL DISPERSAL HYPOTHESES IMPROVES STACKED SPECIES DISTRIBUTION MODEL PERFORMANCE

BY

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Abstract

Stacked distribution models are an important step towards estimating species richness and community composition, but they frequently overpredict these metrics. Developing *a priori* accessible area (*i.e.*, **M**) hypotheses to limit the training area based on known dispersal and biogeographic barriers is one way to limit these overpredictions. In order to test the effectiveness of **M**s for improving model predictions, 293 species of hummingbird (Aves: Trochilidae) were modeled in a uniform training area and within custom **M** hypotheses. Locality data was drawn from the Global Biodiversity Informatics Facility, while 13 pre-determined test localities were selected from well-sampled hotspots available within the eBird database. Circles with a radius of 20 kilometers around the eBird localities were removed from the testing dataset and aggregated into a known species list. These lists were compared to published checklists when available. Niche models were thresholded to create species distributions models (SDMs) and then stacked to form presence-absence matrices (PAMs). PAMs were derived for the aforementioned testing localities and their predictions of species richness and community composition were contrasted against the known data. While unconstrained (*i.e.*, uniformly trained) models possess egregious overpredictions, **M** constrained models perform well and are significantly more accurate at assessing these metrics. Analyzing the amount of overprediction against the amount of effort for each locality also suggests that areas with the most effort are the least likely to possess overpredictions, but this requires further study. Using **M** constrained models is an effective approach for creating near-accurate estimates of species richness and composition, and therefore a much better method for estimating species distributions. Future research should focus on additional methods for improving individual SDMs within the **M** training region as well as further analyzing the effects of effort on comparison results.

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Introduction

Conservation and biodiversity research worldwide has generally been limited and biased towards biodiversity hotspots and regions that are relatively easy to access and well-known (Ponder *et al*., 2001), but gaps in our knowledge of the area of distribution of species (the Wallacean shortfall) are substantial (Whittaker *et al*., 2005). Most of what is known about species' distributions is affected by this incomplete sampling, and is therefore spatially limited and biased from the outset (Reddy and Dávalos, 2003). Species distribution models (SDMs) are seen as an important method towards estimating a species' distributional extent (Feria and Peterson, 2002; Soberón and Peterson, 2005; Peterson *et al*., 2011). Moreover, SDMs can be aggregated and stacked for multiple taxa to predict richness and community composition for a given locality (Graham and Hijmans, 2006; Aranda and Lobo, 2011; Peterson *et al*., 2011), although this method is still developing (Calabrese *et al*., 2013).

One of the most common ways of estimating a species distribution is by creating an ecological niche model (ENM). ENMs use climatic (or other environmental) associations of observed localities to estimate the environmental space (*i.e*., ecological niche) occupied by the species; this "niche model" can then be projected into geographic space to find areas with environments similar to those where the species has been observed (*i.e*., "homocline matching"; Lindenmayer *et al*., 1991; Peterson *et al*., 2011). When true absence data are available, it is possible to estimate the probability of presence, given an environmental combination (Pearce and Boyce, 2006), and therefore an estimation of the occupied area can be derived (henceforth $\mathbf{G}_O$; Soberón, 2010). In such cases, the projection of the niche model to geographic space represents a hypothesis about the actual distribution of the species (a genuine species distribution model).

Unfortunately true-absence data are scarce, and most modeling is performed using presence-only data. In this case, the niche model provides an index of similarity of the environments at a given site to the environmental combinations of places where the species has been observed, and projection of the niche model to geography identifies regions with suitable environments, related to the potential distribution of the species (Soberón and Peterson, 2005; Peterson *et al*., 2011), and denoted by $\mathbf{G}_I$ henceforth. Many algorithms can be used to provide such indices (Elith *et al*., 2006; Chefaoui and Lobo, 2008; Phillips *et al*., 2009; Elith *et al.,* 2011; Peterson *et al*., 2011), reviewed in Franklin (2010), which in turn can then be thresholded to create binary SDMs that predict species' potential distributions in geographic space (Graham and Hijmans, 2006; Peterson *et al*., 2011; Liu *et al*., 2013).

Thresholded SDMs represent a set of coordinate-referenced presence and absence predictions that can be "stacked" (*i.e*., spatially aligned and cell values summed) to create presence-absence matrices (PAMs) and predict the community composition and species richness at any given locality (Ferrier and Guisan, 2006; Pineda and Lobo, 2009; Dubuis *et al*., 2011, Peterson *et al*., 2011; D'Amen *et al*., 2015a and b). Stacked SDMs have been found generally to over-predict richness, which should not be a surprise: unless the modeling process is specifically aimed at estimating $\mathbf{G}_O$, distributional estimates will approximate the larger $\mathbf{G}_I$ (Soberón, 2010). However, estimates of stacked $\mathbf{G}_I$ estimates are correlated to observed species numbers (Pineda and Lobo, 2009; Calabrese *et al*., 2013). Alternative species richness estimates have been derived from macro-ecological models, but these estimates lack the ability to predict community composition and are therefore limited in their usefulness for practical applications (Hawkins *et al*., 2000; Dubuis *et al*., 2011; Calabrese *et al*., 2013).

Whether stacked SDMs can create useful, realistic PAMs is still an open question. Many attempts have been made to make SDM stacks that perform more accurately (Guisan and Rahbek, 2011; D'Amen *et al*., 2015), but their performance is still under criticism (Calabrese *et al*., 2013; Gastón and García-Viñas, 2013). What is clear is that since ENM outputs (estimated from presence-only data and without post-processing) yield estimates of geographic areas that are probably between the true occupied area ($\mathbf{G}_O$) and the potential range ($\mathbf{G}_P$) delimited by physiology and unlimited dispersal abilities (Barve *et al*., 2011; Peterson *et al*., 2011), one needs some method to "reduce" the large estimated area to $\mathbf{G}_O$. The **BAM** diagram (Soberón and Peterson, 2005) suggests a way to mitigate overpredictions by combining biotic (**B**), abiotic (**A**), and dispersal (**M**) characters. ENMs typically estimate directly the environments in **A** and implicitly those in **B**, but ignore effects of **M**. Providing independent hypotheses for dispersal (a.k.a. dispersal areas; **M**s) and using them to constrain outputs of the ENMs reduces the expectation that simple ENMs will produce overpredictions, and should lead to PAMs that better estimate species richness and β-diversity.

In this study, two sets of SDMs were derived to compare how addressing **M** affects predictive ability. An initial set of ENMs was estimated using classic approaches that use a calibration area that is either a continent or the area accessible to the entire clade (Hubbell, 2005). The second set of models estimated true SDMs trained within customized **M**s (Soberón and Peterson, 2005; Barve *et al*., 2011; Owens *et al*., 2013). The latter approach, which has never been applied to a large group of organisms, should yield estimates closer to $\mathbf{G}_O$ rather than to $\mathbf{G}_P$ and should produce better estimates of PAMs.

Methods

Data Description

Primary occurrence data were downloaded for all hummingbird species (Trochilidae) for which data were available from the Global Biodiversity Information Facility (GBIF) using the R 3.0 (R Core Team, 2015) package rgbif (Chamberlain *et al*., 2015) and also directly from eBird in December 2013 (Sullivan *et al*., 2009; eBird, 2012; Global Biodiversity Informatics Facility, 2014). Although eBird data are available via GBIF, some associated metadata are lost in the process, necessitating the separate download. We followed the taxonomy of the 2013 IOC checklist (Gill and Donsker, 2013) except for the west Ecuadorian *Anthracothorax prevostii iridescens*, which was treated separately from other *A. prevostii* populations (see discussion in Ridgely and Greenfield, 2001). eBird data were parsed to remove all records that listed distances >10 km or >900 minutes of effort, as a precaution against using locality data drawn from checklists that covered multi-day effort or areas significantly different from the plotted locality (*e.g.*, some tour participants place their entire trips on a single checklist in a country's centroid). eBird and GBIF data were subsequently merged, with duplicate localities removed and rarefied to a minimum interpoint distance of 10 kilometers in R 3.0 (J. D. Manthey, unpub. code; Vavrek, 2011; R Core Team, 2015). Each species was individually inspected to remove any obvious erroneous localities. Localities were compared to existing range maps from online databases (Ridgely *et al*., 2005; BirdLife International, 2014), regional field guides (Howell and Webb, 1995; Ridgely and Greenfield, 2001; Hilty, 2003; Raffaele *et al*., 2003; Schulenberg *et al*., 2007), and species accounts in the *Handbook of the Birds of the World* (Schuchmann, 1999). Migratory species with discrete breeding and wintering ranges or with breeding ranges extending broadly out of the tropics were represented by their winter distribution in analyses (Howell and

Webb, 1995; Schuchmann, 1999; eBird, 2012), which we considered more representative of their distributions at testing localities (Martínez-Meyer *et al*., 2004; Nakazawa *et al*., 2004; Guisan *et al*., 2006). Questionable locality records were researched to determine whether they were truly erroneous locality records or valid (*i.e.*, substantiated or experienced and trustworthy observer) reports (eBird, 2012; M. J. Anderson, pers. comm.; M. Brady, pers. comm.; M. G. Harvey, pers. comm.; P. Hosner, pers. comm.; J. D. Wolfe, pers. comm.; see aforementioned literature). Records representing vagrants (*i.e.*, valid singleton records far from established populations), unsubstantiated reports, or incorrectly georeferenced localities were removed from the database before creating ENMs**.** Species for which there were fewer than five occurrence points after test locality removal were excluded, as were other species that are now extinct or whose ranges were never accurately known. A complete list of species that were and were not modeled can be found in Appendix 1.

Localities at which to test model predictions were selected non-randomly from well-sampled areas located between 25° N and 25° S, with one locality per 5° band per continent and two additional equatorial (*i.e.*, within ½° of the Equator) localities, for a total of 13 localities (Fig. 1). These localities were selected based on data availability in eBird, and on the amount of effort (*i.e.*, complete eBird checklists as of April 2015) associated with each (eBird, 2012). Localities possessing high species richness and extensive effort were preferred, but, where disparities existed, effort was chosen as a more important metric for validating estimations. To prevent using these test localities within the training models, buffers of 20 km were chosen around the coordinates of each location were used to remove other presence records; this buffer diameter was chosen to eliminate the possibility of incorrectly-placed coordinates, and to account for 'lumping' of localities in many databases and checklists (*e.g.*, Arvin 2001).

Species Modeling

Climate data were drawn from the BIOCLIM dataset available through the WorldClim database at a spatial resolution of 2.5' (Hijmans *et al*., 2005). Four "bioclimatic" layers were used to calibrate models: mean temperature of the warmest quarter, mean temperature of the coldest quarter, precipitation of the wettest quarter, and precipitation of the driest quarter. These four layers were chosen because they represent the climatic extrema that often constrain species' distributions, and because most other bioclimatic layers are derived from different combinations of or tightly correlated with these variables (Root, 1988). Initial tests of ENMs using only these four variables created SDMs that matched known distributions (Howell and Webb, 1995; Schuchmann, 1999; Ridgely *et al*., 2005; Schulenberg *et al*., 2007).

Locality data were overlaid on terrain basemaps in ArcGIS 10.2 to understand the general geographic area in which each species occurs (ESRI, 2011). To reduce bias further, a world ecoregions layer was added to identify breaks in habitat and identify ecological regions in topographically homogenous areas (World Wildlife Fund, 2011). The distribution of known occurence localities (known as **G+**) and accessible areas (**M**) were used to create biogeographically defined calibration areas (hypothetical **M**s) for ENMs (Soberón and Peterson, 2005). **M**s were constrained by deep valleys (*e.g.*, the Río Marañon), the crests of mountains, and other distinct barriers to species' distributions. In uninterrupted lowland regions, vagrancy was used to bound dispersal limits, so buffers of *ca.* 200-300 km were created around populations lacking defined dispersal barriers, and buffers extended into adjacent ecoregions. Boundaries were kept consistent among taxa as much as possible (*e.g.*, multiple species bounded by a river/mountain range were assumed to have identical or near-identical limits at said barrier).

These **M** hypotheses improve model performance and provide an *a priori* constraint on predictions. The ENM prediction bounded by **M** is regarded as a prediction of $\mathbf{G}_O$ (*i.e.*, a SDM *sensu stricto*; Soberón, 2010; Barve *et al*., 2011). SDMs were successfully created for 293 species of hummingbird, representing 85.6% of all described species.Tests of different calibration areas to explore the effects of calibration were conducted on extensiveness of training areas for *Phaethornis striigularis.* These tests indicated that using broad calibration areas artificially restrict the projected range, whereas tightly fitted calibration areas (*e.g.*, minimum convex polygons enclosing occurrence points) greatly over-predicted species' distribution. Restricting calibration areas to regions bounded by abiotic barriers (*e.g.* large rivers, mountain ranges) and known dispersal distances yielded more accurate models and reduced errors (Barve *et al*., 2011; Royle *et al*., 2012; Saupe *et al*., 2012; Owens *et al*., 2013).

An additional neutral training area of all regions inhabited by hummingbirds was used to calibrate an additional set of models. This area was roughly defined as the entire area over which hummingbirds are known to have occured within recent geologic history, including all of continental North and South America, the Caribbean, the Juan Fernández Islands, and the Aleutian and Bering Sea Islands. Island archipelagos that do not possess hummingbirds (*i.e.*, the Canadian Arctic Archipelago, Falkland Islands, etc.) were excluded from the calibration area.

Data layers were clipped to the same extent as calibration regions in R 3.0 (R Core Team, 2015) using the packages ENMGadgets (Barve and Barve, 2014), maptools (Bivand and Lewin-Koh, 2015), raster (Hijmans, 2015), rgdal (Bivand *et al*., 2015), shapefiles (Stabler, 2013), and sp (Pebesma and Bivand, 2005). Models were created using MAXENT 3.3 (Phillips *et al*., 2004) within R 3.0 (R Core Team, 2015) using the packages dismo (Hijmans *et al*., 2015) and rJava (Urbanek, 2013). Five replicates of each model were conducted with no clamping or

extrapolation, with the average raw output saved. Outputs were thresholded using a fixed sensitivity of 95% to create binary outputs. Despite arguments for maximizing the sum of sensitivity and specificity in thresholding such predictions, a 95% threshold was chosen to reflect confidence in data quality and increased certainty of presence over absence localities (Peterson *et al*., 2011; Liu *et al*., 2013). PAMs extended from the original **M** extent to the common, hemispheric extent described above, and stacked to create a final richness raster. For test localities, we included species predicted to find suitable conditions in at least 25% of the area within 20 km of the point.

Contrasting Predictions and Methods

Thirteen localities regarded as well-sampled (therefore providing information about true absences) were selected based on JCC's knowledge of the data. Species lists for each locality were drawn from the eBird data, using existing published checklists when available (see Arvin, 2001; Tropical Birding, 2005; Wilderness Explorers, 2008; Copalinga Lodge, 2013; Lees *et al*., 2013; Costa Rica Gateway, 2015; Serra dos Tucanos Birding Tours, 2015). Pre-2013 eBird occurrence data from within 20 km of localities were aggregated to represent a locality's observational data, whereas post-2013 data were gleaned directly from the eBird website (Vavrek, 2011; eBird, 2012). eBird observational data were compared directly with existing checklists to detect discrepancies, and a combined master list was created for each site. This concatenation was necessary because 1) checklists varied in area treated around a locality and did not always include all areas within the 20 km buffer; and 2) many checklists have not been updated, whereas eBird checklists are continuously reviewed and updated. Two localities had checklists that may have exceeded the 20 km radius: Municipo [sic; Municipio] Gómez Farías, Tamaulipas, Mexico and Rio Cristalino (a.k.a. Alta Floresta), Mato Grosso, Brazil. Municipio

Gómez Farías was considered acceptable for comparison as it occurs at a rather northern latitude with few micro-endemics and rather homogeneous bird communities, and Rio Cristalino was considered acceptable as it is in a climatically homogenous lowland region.

The completeness index (*c*) was calculated by dividing the number of observed species (*o*) by the number of expected species (*e*) for each locality (Hawkins *et al*., 2000), and was used to evaluate site adequacy for predicting gross richness. The number of observed species was divided by the number of expected species for each locality to determine the amount of overprediction, with an ideal prediction having a completeness index of one so that $o = c \times e$. Richness estimations were further compared using the prediction success (*p*) metric as defined by d'Amen *et al.* (2015) relating the number of true predictions (*tp*) and true absences (*ta*) to the total species pool (*sp*).

$$p = \frac{tp + ta}{sp}$$

The completeness index (*c*) was further compared directly to the amount of effort at each location (*f*). *f* was approximated by using the number of complete eBird checklists submitted to each location 'hotspot' as of April 2015 (eBird, 2012). A non-linear regression was performed of *c* related to *f*, where *a* is the rate of increase and *A* is the asymptote of the relationship and interpretable as the theoretical optimum of *c* with the given data. If models perform perfectly, then *A* will equal 1.

$$c = \frac{A \times f}{a + f}$$

The Sørensen index (s_i) was used to assess model accuracy with regard to community accuracy per site (D'Amen *et al*., 2015). The prediction related the number of true predictions (*tp*) to the number of false absences (*fa*) and false predictions (*fp*).

$$s_i = \frac{2tp}{2tp + fa + fp}$$

Just like *c*, s_i was directly compared to *f* using a non-linear regression with an asymptote of *A* that was interpretable as the optimal s_i under current modeling parameters and a rate of *a*.

Furthermore, an additional regression of the completeness index *c* was performed against the number of complete eBird checklists at a given locality. These regressions were designed to test whether the highest overpredictions exist at the areas with the least amount of observer coverage or if these overpredictions are constant regardless of observer effort. Given that the number of species recorded at a locality should increase indefinitely, it was predicted that overpredictions should lessen as observer coverage increases. These comparisons were conducted using only **M**-constrained *c* based on the 2015 data, and only with localities that possessed ≥100 complete eBird checklists.

Results

Comparing the results of species presence lists derived from 2013 and 2015 data revealed that multiple 'false predictions' have since been validated (Appendix 2). Given the amount of data added, only the 2015 data was used to assess model effectiveness.

Comparing Model Performance

The prediction success of models that were and were not constrained by accessible area hypotheses was significantly different (Wilcoxon rank sum test, $W = 168$, $P < 0.001$), with the success of constrained models ($c = 0.95 \pm 0.01$) being greater than unconstrained models (0.71 ± 0.08; Fig. 2). Sørensen indices indicated that unconstrained models differed significantly from their constrained counterparts (Wilcoxon rank sum test, $W = 2$, $P < 0.001$), with constrained

models providing more complete estimates of community composition (0.77±0.05) than unconstrained models (0.39±0.05; Fig. 2).

Regressions of the completeness index (*c*) further illustrate the overpredictions present in unconstrained models. Unconstrained models yield a slope of 0.27±0.03 (R^2 = 0.93), indicating consistent and extreme overpredictions of species richness when these ENMs are used. Conversely, **M**-constrained models predicted species richness with a slope of 0.77±0.13 (R^2 = 0.96; Fig. 3). Both regressions had high R^2 values, and both reflect a clear relationship between the number of species known at a locality and the number predicted. Despite this, **M**-constrained models were far more accurate at predicting species richness than unconstrained models.

Effects of Effort

The initial restriction of data to ≥100 complete eBird checklists improved **M**-constrained model performance when predicting species richness (c = 0.79 ± 0.13). When the completion indices of localities were regressed with respect to the total number of checklists, the value of c is found to have an asymptote of 1.22 with a standard error of 0.27. Combined with the fact that several localities were underpredicted (*e.g.* Rio Cristalino, Mato Grosso, Brazil), these results suggest that **M**-constrained PAMs may actually underpredict species richness. Similarly, regressions of the Sørensen indices found an asymptote of 0.80 and a standard error of 0.04, supporting the notion that localities with extensive effort still do not have all species represented in community predictions. These results support the hypothesis that model performance increase as the amount of effort increases, but also suggest that the number of species confirmed at a site will continue to grow and eventually surpass the number of species predicted at a locality.

Discussion

This study is a case of a "predict first, assemble later" strategy to estimate the composition of communities (D'Amen *et al*., 2015b), but it is the first case where stacking was constrained by hypotheses about species' dispersal and access to geographic regions. As such, it constitutes a novel approach to stacking as a method to understand the geographic pattern of species richness (Soberón and Peterson, 2005; Soberón, 2010; Peterson *et al*., 2011). Lack of detailed data on dispersal has been cited as major factor hindering a more widespread use of process-oriented SDMs (Hortal *et al*. 2012), but our method is less-demanding since there is no need to calculate dispersal kernels. Nevertheless, sSDMs constrained *a priori* in their geographic extent perform better in anticipating geographic patterns of species richness than models that lack dispersal-based constraints (Soberón and Peterson, 2005; Guisan *et al*., 2006; Soberón, 2010; Barve *et al*., 2011). Restricting the calibration area to a species' **M** creates more accurate and precise predictions of the species' true occupied geographic distribution ($\mathbf{G}_O$), increasing the predictive power of SDMs in environmental space and eliminating overlap of allopatric species complexes (Soberón and Peterson, 2005; Barve *et al*., 2011; Owens *et al*., 2013; Fig. 4). Furthermore, these models reduce bias in ENMs and SDMs by removing regions in which any estimations would be created via extrapolations from known environmental tolerances (Saupe *et al*., in prep.; Owens *et al*., 2013), and offer improved confidence in individual model performance.

These factors are further reinforced by the high overpredictions present in many montane systems, where similar regions with similar species assemblages are often separated by large canyons or lowlands. Enforcing dispersal limitations not only results in a better reflection of $\mathbf{G}_P$ by restricting **A**, but also by implicitly accounting for interactions in **B** by limiting the environments in which species can co-occur (Cooper and Barragan, *in prep*.). The performance

of these models rejects the notion that a neutral biogeographic model of $\mathbf{G}_P$ is appropriate for creating a single training area for multiple evolutionary units, and draws attention to an oft-neglected part of the modeling process.

M-derived PAMs underperformed slightly when predicting species present within communities, and generally possess more commission than omission error (*i.e.*, generally overpredict community compositions). This was considered preferable for community composition, as it is less likely that species of conservation concern will be excluded from population predictions. Despite this, both commission and omission can be harmful to conservation efforts; further reducing commission error in the future is a necessity to ensure the proper allocation of conservation funds and creation of effective reserves (Loiselle *et al*., 2003). In all regions for which predictions of community composition are made, a certain amount of survey work is also required to confirm the model's accuracy and identify possible errors (Pineda and Lobo, 2009).

Effects of Effort

In this study, three localities were underpredicted in terms of species richness: Municipio Gómez Farías, Tamaulipas, México; Rancho Naturalista, Cartago, Costa Rica; and Río Cristalino, Mato Grosso, Brazil, which falls within the well-surveyed Alta Floresta region (Zimmer *et al*., 1997; Lees *et al*., 2013). All of these localities had seen an enormous amount of effort (>140 complete eBird checklists per centroid), and possess official published checklists (Arvin, 2001; Lees *et al*., 2013; Costa Rica Gateway, 2015). False negatives at these locations are likely related to three factors: occasional migrants and vagrants that occur in adjacent regions but that are not resident at the test locality (*e.g.*, *Amazilia rutila*, Rancho Naturalista), highly localized species that were predicted at a locality but that fall below the 25% occupancy

threshold (*e.g.*, *Atthis heliosa*, Municipio Gómez Farías), and genuine prediction errors by the model (*e.g.*, *Topaza pella*, Rio Cristalino).

Conversely, many overpredictions appear to be attributable to insufficient survey effort. Many validated predictions were in regions of topographic complexity, suggesting that survey effort is concentrated in accessible regions, rather than covering the entire site (Ponder *et al*., 2001). Between the original data download (2013) and the study's end (2015), there were 22 site record confirmations of predicted species. For instance, at RNA Reinita Cielo Azul, Santander, Colombia, six predictions were confirmed (Appendix 2); many of the remaining false positive predictions refer to species perhaps yet be found in rugged areas away from access points (*e.g.*, *Ensifera ensifera*). While the number of test localities in this study was insufficient to narrow estimates of the asymptote of *c* using **M**-constrained models, we can not exclude the possibility of PAMs derived from sSDMs underpredicting species richness. Estimates of the value of s_i were more precise, with a theoretical asymptote near 0.80. This denotes that **M**-constrained models predict most species in a community, which is not possible with macroecological models (Dubuis *et al*., 2011).

*Improving Upon **M** SDMs*

Many factors that limit species' distributions in the neotropics (*e.g.*, elevational effects on metabolism, biotic interactions and specificity for different habitat types) were not accounted for in these basic ecological models (Altshuler and Dudley, 2002; Buermann, *et al*., 2011). Despite acceptable overall model performance using only four BIOCLIM variables, several species that are limited by other factors had poorly performing ENMs. One glaring example is *Leucippus chlorocercus*, restricted to riparian-scrub along large rivers in western Amazonia (Schuchmann, 1999; Ridgely and Greenfield, 2001; Schulenberg *et al*., 2007): this species' SDM does not

conform to rivers within the region, and omits the test locality from which the species is known to occur (Sacha Lodge, Sucumbíos, Ecuador).

Unique biotic relationships can be used to refine SDMs further. Hummingbirds are well known to be associated with certain species of flowers (*e.g.*, *Heliconia*), and many possess unique bill morphologies reflecting these close relationships (Stiles, 1975; Schuchmann, 1999). Furthermore, interactions between species may also be restricting distributions, as many erroneous predictions overlapped with related allo- or parapatric taxa (*e.g.*, *Coeligena coeligena* vs. *C. wilsoni* in the western Andes). More research into how to mitigate these contingencies is necessary to create better models of species distributions, especially in areas of parapatry. As more data regarding these species become available, characterizing species-specific biotic limitations may become possible.

Initial studies have shown that using remote-sensing data, like the Normalized Difference Vegetation Index (NDVI) can improve sSDM models originally based only on climatic data layers (Cord *et al*., 2014; Jiang *et al*., 2014). These data show great potential for species with poor dispersal abilities (*e.g.*, *Pinus*), but are extremely difficult to spatiotemporally correlate with motile animal occurences. Even when this is accomplished, restricting these additional layers to the regions that the species can explore is still imperative, and using such data without caution may result in egregious errors.

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Appendix 1: Figures

Index

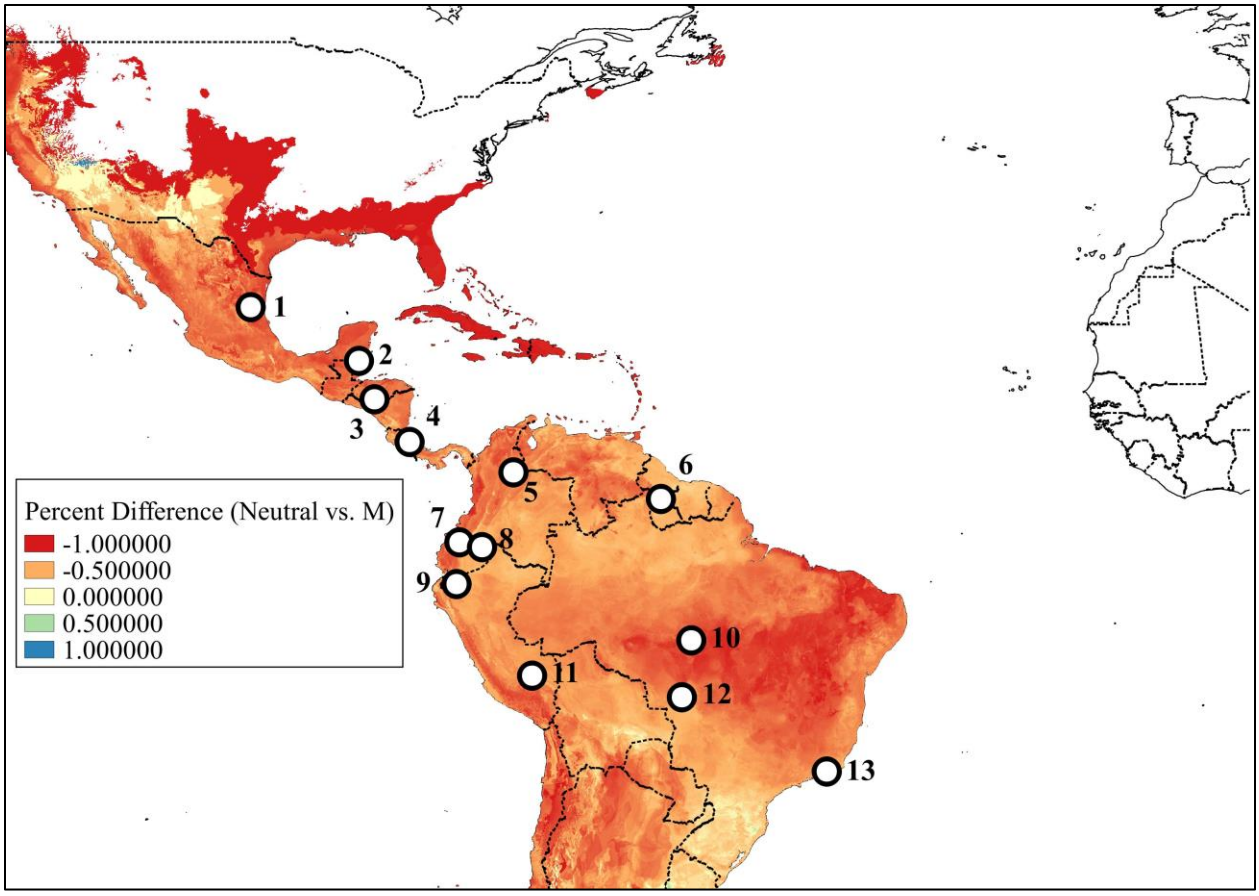

Figure 1. Map of percent difference between neutral and **M** thresholded models with testing localities indicated. Areas with smaller (*i.e.*, more negative) values are overpredicted most using neutral models. Test localities used in this analysis are numbered from north to south: 1) Municipo[sic] Gómez Farías, Tamaulipas, México; 2) Crooked Tree Wildlife Sanctuary, Orange Walk, Belize; 3) Zamorano University Campus Farms and River, Francisco Morazán, Honduras; 4) Rancho Naturalista, Cartago, Costa Rica; 5) RNA Reinita Cielo Azul, Santander, Colombia; 6) Atta Lodge, Potaro-Siparuni, Guyana; 7) Tandayapa Bird Lodge, Pichincha, Ecuador; 8) Sacha Lodge, Sucumbíos, Ecuador; 9) Copalinga Lodge, Zamora-Chinchipe, Ecuador; 10) Rio Cristalino [Alta Floresta/Cristalino Lodge Area], Mato Grosso, Brazil; 11) Cock-of-the-Rock Lodge,

Cuzco, Perú; 12) Curupira Lodge (Serra das Araras), Mato Grosso, Brazil; 13) Serra dos Tucanos Lodge, Rio de Janeiro, Brazil.

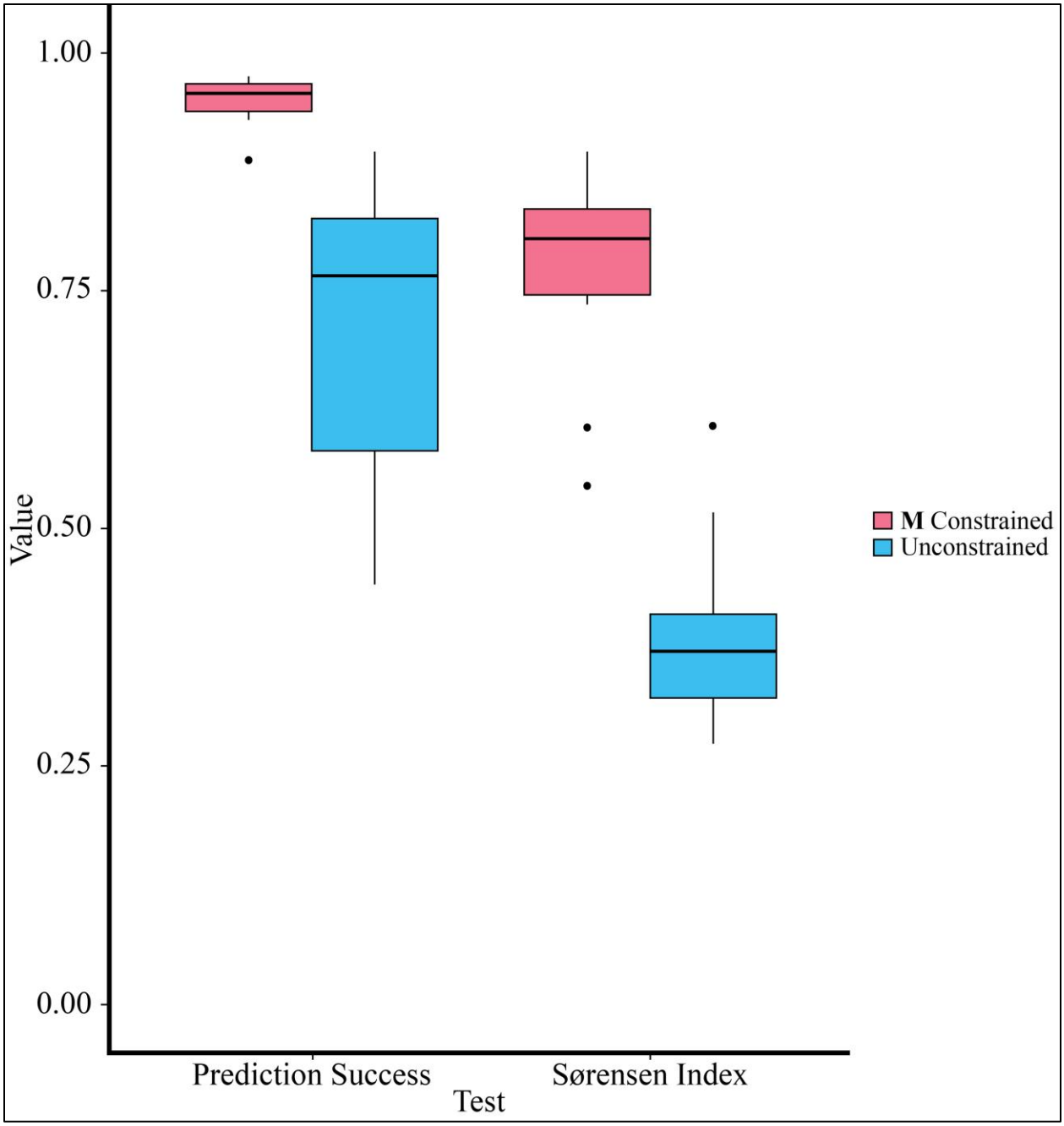

Figure 2: Comparisons of richness (prediction success) and community composition (Sørensen index) estimations between **M** constrained and neutral based training regions.

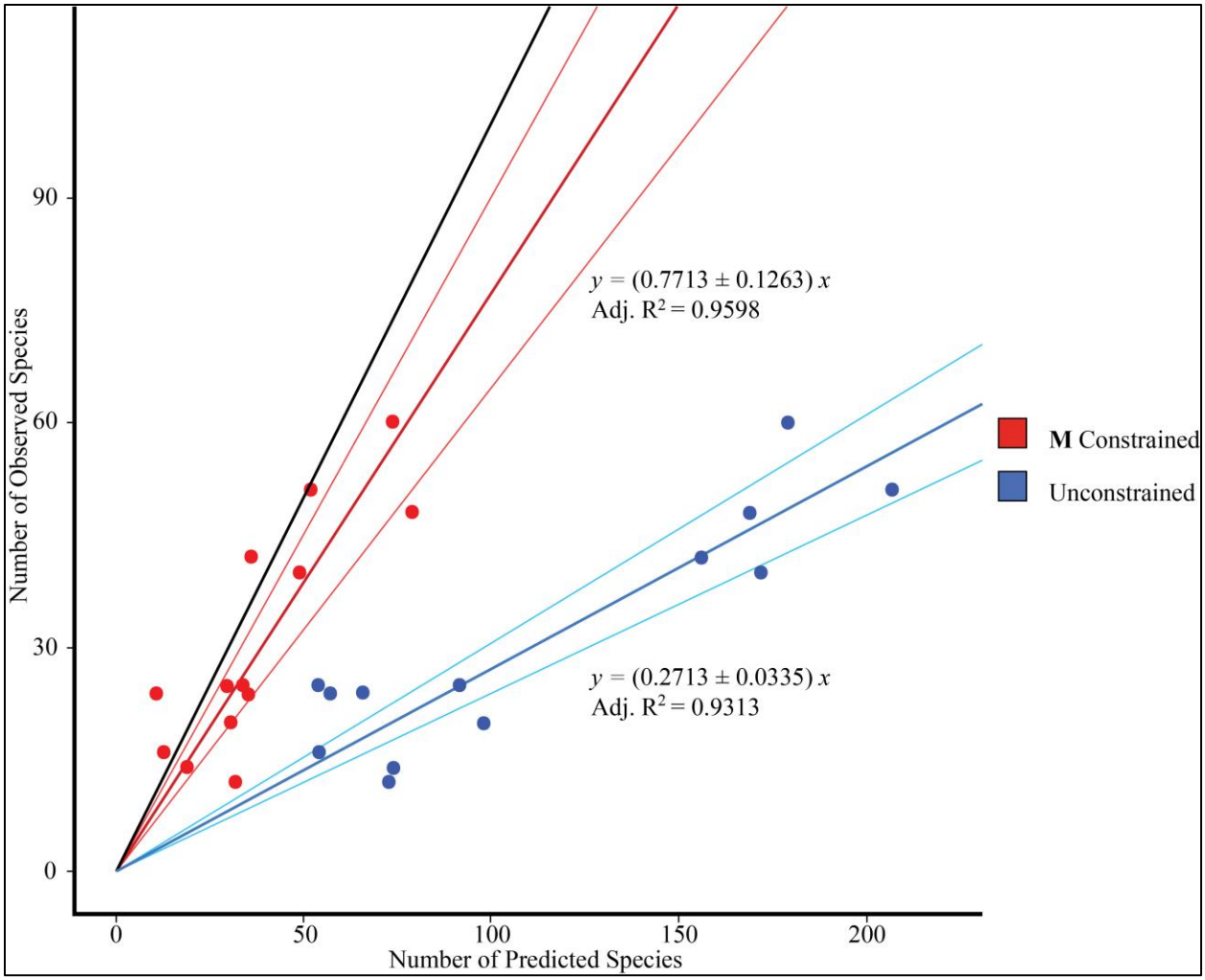

Figure 3: Completion index (*c*) regressions using neutral and **M** thresholded models. Bold lines represent recovered regression lines, while their flanking lines show the 95% confidence intervals. The black line shows an ideal *c* of with a slope of 1.

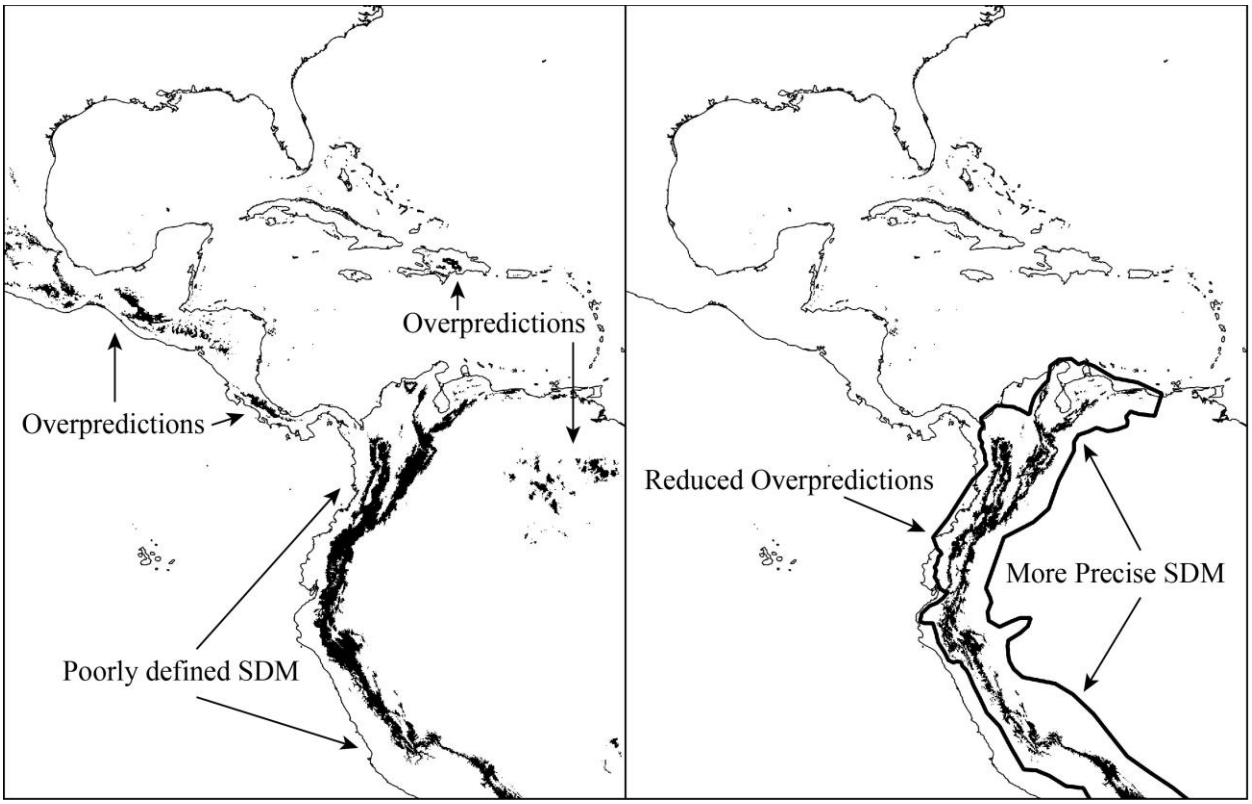

Figure 4. A comparison between unconstrained (**A**) and **M**-constained (**B**) SDMs of *Coeligena coeligena*. **A** shows egregious overpredictions and an ill-defined SDM within the species' known area of distribution (the Andes, South America). **B**, including an outline of the **M** training area used, yields a much more precise SDM with limited overpredictions (namely, as indicated in western Ecuador, where the species is replaced by *Coeligena wilsoni*).

Appendix 2: Species List

Complete list of species used in this study, with notes as to whether they were included or excluded in this analysis. Excluded species are annotated with their reason for exclusion and which (if any) localities were affected by their exclusion. Species are listed in taxonomic order (Gill and Donsker, 2013).

#	Species	Modeled	Excluded	Reason	Localities Affected
1	*Ramphodon naevius*	X			
2	*Eutoxeres aquila*	X			
3	*Eutoxeres condamini*	X			
4	*Glaucis dohrnii*		X	Five or fewer occurrence points.	
5	*Glaucis hirsutus*	X			
6	*Glaucis aeneus*	X			
7	*Threnetes ruckeri*	X			
8	*Threnetes niger*		X	Five or fewer occurrence points.	
9	*Threnetes leucurus*	X			
10	*Anopetia gounellei*		X	Five or fewer occurrence points.	
11	*Phaethornis yaruqui*	X			
12	*Phaethornis guy*	X			
13	*Phaethornis hispidus*	X			
14	*Phaethornis longirostris*	X			
15	*Phaethornis superciliosus*	X			
16	*Phaethornis malaris*	X			
17	*Phaethornis syrmatophorus*	X			
18	*Phaethornis koepckeae*	X			
19	*Phaethornis philippii*	X			
20	*Phaethornis bourcieri*	X			
21	*Phaethornis anthophilus*	X			
22	*Phaethornis eurynome*	X			
23	*Phaethornis pretrei*	X			
24	*Phaethornis augusti*	X			
25	*Phaethornis subochraceus*	X			
26	*Phaethornis squalidus*	X			
27	*Phaethornis rupurumii*	X			

28	*Phaethornis longuemareus*	X			
29	*Phaethornis idaliae*	X			
30	*Phaethornis nattereri*	X			
31	*Phaethornis ruber*	X			
32	*Phaethornis stuarti*	X			
33	*Phaethornis atrimentalis*	X			
34	*Phaethornis aethyopyga*		X	Five or fewer occurrence points.	Cristalino Lodge
35	*Phaethornis striigularis*	X			
36	*Phaethornis griseogularis*	X			
37	*Androdon aequatorialis*	X			
38	*Doryfera ludovicae*	X			
39	*Doryfera johannae*	X			
40	*Phaeochroa cuvierii*	X			
41	*Campylopterus curvipennis*	X			
42	*Campylopterus pampa*	X			
43	*Campylopterus excellens*	X			
44	*Campylopterus largipennis*	X			
45	*Campylopterus rufus*	X			
46	*Campylopterus hyperythrus*	X			
47	*Campylopterus hemileucurus*	X			
48	*Campylopterus ensipennis*	X			
49	*Campylopterus falcatus*	X			
50	*Campylopterus phainopeplus*		X	Five or fewer occurrence points.	
51	*Campylopterus villaviscensio*	X			
52	*Campylopterus duidae*		X	Five or fewer occurrence points.	
53	*Aphantochroa cirrochloris*	X			
54	*Eupetomena macroura*	X			
55	*Florisuga mellivora*	X			

56	*Florisuga fusca*	X		
57	*Colibri delphinae*	X		
58	*Colibri thalassinus*	X		
59	*Colibri coruscans*	X		
60	*Colibri serrirostris*	X		
61	*Anthracothorax viridigula*	X		
62	*Anthracothorax prevostii*	X		
63	*Anthracothorax [prevostii] iridescens*	X		
64	*Anthracothorax nigricollis*	X		
65	*Anthracothorax veraguensis*	X		
66	*Anthracothorax dominicus*	X		
67	*Anthracothorax viridis*	X		
68	*Anthracothorax mango*	X		
69	*Avocettula recurvirostris*	X		
70	*Topaza pella*	X		
71	*Topaza pyra*	X		
72	*Eulampis jugularis*		X	Continual errors in model performance.
73	*Eulampis holosericeus*	X		
74	*Chrysolampis mosquitus*	X		
75	*Orthorhynchus cristatus*	X		
76	*Klais guimeti*	X		
77	*Stephanoxis lalandi*	X		
78	*Abeillia abeillei*	X		
79	*Lophornis ornatus*	X		
80	*Lophornis gouldii*		X	Five or fewer occurrence points.
81	*Lophornis magnificus*	X		
82	*Lophornis brachylophus*		X	Five or fewer occurrence points.
83	*Lophornis delattrei*	X		

84	*Lophornis stictolophus*	X		
85	*Lophornis chalybeus*	X		
86	*Lophornis pavoninus*	X		
87	*Lophornis helenae*	X		
88	*Lophornis adorabilis*	X		
89	*Discosura popelairii*	X		
90	*Discosura langsdorffi*	X		
91	*Discosura letitiae*		X	Data deficient.
92	*Discosura conversii*	X		
93	*Discosura longicaudus*	X		
94	*Trochilus polytmus*	X		
95	*Trochilus scitulus*		X	Five or fewer occurrence points.
96	*Chlorestes notata*	X		
97	*Chlorostilbon auriceps*	X		
98	*Chlorostilbon forficatus*		X	Five or fewer occurrence points.
99	*Chlorostilbon canivetii*	X		
100	*Chlorostilbon assimilis*	X		
101	*Chlorostilbon mellisugus*	X		
102	*Chlorostilbon melanorhynchus*	X		
103	*Chlorostilbon gibsoni*	X		
104	*Chlorostilbon olivaresi*		X	Five or fewer occurrence points.
105	*Chlorostilbon lucidus*	X		
106	*Chlorostilbon bracei*		X	Extinct. Five or fewer occurrence points.
107	*Chlorostilbon ricordii*	X		
108	*Chlorostilbon swainsonii*	X		
109	*Chlorostilbon maugaeus*	X		
110	*Chlorostilbon russatus*		X	Five or fewer occurrence points.
111	*Chlorostilbon stenurus*	X		

112	*Chlorostilbon alice*	X		
113	*Chlorostilbon poortmani*	X		
114	*Chlorostilbon elegans*		X	Extinct. Data deficient.
115	*Panterpe insignis*	X		
116	*Elvira chionura*	X		
117	*Elvira cupreiceps*	X		
118	*Eupherusa cyanophrys*	X		
119	*Eupherusa poliocerca*	X		
120	*Eupherusa eximia*	X		
121	*Eupherusa nigriventris*	X		
122	*Goethalsia bella*		X	Five or fewer occurrence points.
123	*Goldmania violiceps*		X	Five or fewer occurrence points.
124	*Cynanthus sordidus*	X		
125	*Cynanthus latirostris*	X		
126	*Cynanthus doubleayi*	X		
127	*Cyanophaia bicolor*	X		
128	*Thalurania ridgwayi*	X		
129	*Thalurania colombica*	X		
130	*Thalurania furcata*	X		
131	*Thalurania watertonii*	X		
132	*Thalurania glaucopis*	X		
133	*Damophila julie*	X		
134	*Lepidopyga coeruleogularis*	X		
135	*Lepidopyga lilliae*		X	Five or fewer occurrence points.
136	*Lepidopyga goudoti*	X		
137	*Hylocharis eliciae*	X		
138	*Hylocharis sapphirina*	X		
139	*Hylocharis cyanus*	X		

140	*Hylocharis chrysura*	X			
141	*Hylocharis grayi*	X			
142	*Hylocharis humboldtii*		X	Five or fewer occurrence points.	
143	*Chrysuronia oenone*	X			
144	*Leucochloris albicollis*	X			
145	*Polytmus guainumbi*	X			
146	*Polytmus milleri*	X			
147	*Polytmus theresiae*	X			
148	*Leucippus fallax*	X			
149	*Leucippus baeri*	X			
150	*Leucippus taczanowskii*	X			
151	*Leucippus chlorocercus*	X			
152	*Taphrospilus hypostictus*	X			
153	*Amazilia chionogaster*	X			
154	*Amazilia viridicauda*	X			
155	*Amazilia rutila*	X			
156	*Amazilia yucatanensis*	X			
157	*Amazilia tzacatl*	X			
158	*Amazilia castaneiventris*		X	Five or fewer occurrence points.	RNA Reinita Azul
159	*Amazilia amazilia*	X			
160	*Amazilia leucogaster*	X			
161	*Amazilia versicolor*	X			
162	*Amazilia brevirostris*	X			
163	*Amazilia franciae*	X			
164	*Amazilia candida*	X			
165	*Amazilia cyanocephala*	X			
166	*Amazilia violiceps*	X			
167	*Amazilia viridifrons*	X			

168	*Amazilia wagneri*	X		
169	*Amazilia fimbriata*	X		
170	*Amazilia lactea*	X		
171	*Amazilia amabilis*	X		
172	*Amazilia decora*	X		
173	*Amazilia rosenbergi*	X		
174	*Amazilia boucardi*	X		
175	*Amazilia luciae*	X		
176	*Amazilia saucerottei*	X		
177	*Amazilia cyanifrons*	X		
178	*Amazilia edward*	X		
179	*Amazilia cyanura*	X		
180	*Amazilia beryllina*	X		
181	*Amazilia viridigaster*	X		
182	*Amazilia tobaci*	X		
183	*Microchera albocoronata*	X		
184	*Anthocephala floriceps*		X	Five or fewer occurrence points.
185	*Chalybura buffonii*	X		
186	*Chalybura urochrysia*	X		
187	*Lampornis clemenciae*	X		
188	*Lampornis amethystinus*	X		
189	*Lampornis viridipallens*	X		
190	*Lampornis sybillae*	X		
191	*Lampornis hemileucus*	X		
192	*Lampornis calolaemus*	X		
193	*Lampornis castaneoventris*		X	Five or fewer occurrence points.
194	*Lampornis cinereicauda*	X		
195	*Basilinna [Hylocharis] xantusii*	X		

196	*Basilinna [Hylocharis] leucotis*	X			
197	*Lamprolaima rhami*	X			
198	*Adelomyia melanogenys*	X			
199	*Phlogophilus hemileucurus*	X			
200	*Phlogophilus harterti*		X	Five or fewer occurrence points.	Cock-of-the-rock Lodge
201	*Clytolama rubricauda*	X			
202	*Heliodoxa xanthogonys*	X			
203	*Heliodoxa gularis*		X	Five or fewer occurrence points.	
204	*Helidoxa branickii*	X			
205	*Heliodoxa schreibersii*	X			
206	*Heliodoxa aurescens*	X			
207	*Heliodoxa rubinoides*	X			
208	*Heliodoxa jacula*	X			
209	*Heliodoxa imperatrix*	X			
210	*Heliodoxa leadbeateri*	X			
211	*Eugenes fulgens*	X			
212	*Hylonympha macrocerca*		X	Five or fewer occurrence points.	
213	*Sternoclyta cyanopectus*	X			
214	*Urochroa bougueri*	X			
215	*Boissonneaua flavescens*	X			
216	*Boissonneaua matthewsii*	X			
217	*Boissonneaua jardini*	X			
218	*Aglaeactis cupripennis*	X			
219	*Aglaeactis aliciae*		X	Five or fewer occurrence points.	
220	*Aglaeactis castelnaudii*	X			
221	*Aglaeactis pamela*	X			
222	*Oreotrochilus chimborazo*	X			
223	*Oreotrochilus estella*	X			

224	*Oreotrochilus leucopleurus*	X			
225	*Oreotochilus melanogaster*	X			
226	*Oreotrochilus adela*	X			
227	*Lafresnaya lafresnayi*	X			
228	*Coeligena coeligena*	X			
229	*Coeligena wilsoni*	X			
230	*Coeligena prunellei*	X			
231	*Coeligena torquata*	X			
232	*Coeligena phalerata*		X	Five or fewer occurrence points.	
233	*Coeligena bonapartei*	X			
234	*Coeligena orina*		X	Five or fewer occurrence points.	
235	*Coeligena helianthea*	X			
236	*Coeligena lutetiae*	X			
237	*Coeligena violifer*	X			
238	*Coeligena iris*	X			
239	*Ensifera ensifera*	X			
240	*Pterophanes cyanopterus*	X			
241	*Patagona gigas*	X			
242	*Sephanoides sephanoides*	X			
243	*Sephanoides fernandensis*		X	Five or fewer occurrence points.	
244	*Heliangelus mavors*	X			
245	*Heliangelus amethysticollis*	X			
246	*Heliangelus strophianus*		X	Five or fewer occurrence points.	Tandayapa Lodge.
247	*Heliangelus exortis*	X			
248	*Heliangelus micraster*		X	Five or fewer occurrence points.	
249	*Heliangelus viola*	X			
250	*Heliangelus zusii*		X	Possibly Extinct. Data deficient.	
251	*Heliangelus regalis*	X			

252	*Eriocnemis nigrivestis*		X	Five or fewer occurrence points.	Tandayapa Lodge.
253	*Eriocnemis isabellae*		X	Five or fewer occurrence points.	
254	*Eriocnemis vestita*	X			
255	*Eriocnemis derbyi*	X			
256	*Eriocnemis godini*		X	No positively known localities.	
257	*Eriocnemis cupreoventris*	X			
258	*Eriocnemis luciani*	X			
259	*Eriocnemis mosquera*	X			
260	*Eriocnemis glaucopoides*	X			
261	*Eriocnemis mirabilis*		X	Five or fewer occurrence points.	
262	*Eriocnemis aline*	X			
263	*Haplophaedia aureliae*	X			
264	*Haplophaedia assimilis*	X			
265	*Haplophaedia lugens*		X	Five or fewer occurrence points.	Tandayapa Lodge.
266	*Urosticte benjamini*	X			
267	*Urosticte ruficrissa*	X			
268	*Ocreatus underwoodii*	X			
269	*Lesbia victoriae*	X			
270	*Lesbia nuna*	X			
271	*Sappho sparganura*	X			
272	*Polyonymus caroli*	X			
273	*Ramphomicron dorsale*		X	Five or fewer occurrence points.	
274	*Ramphomicron microrhynchum*	X			
275	*Oreonympha nobilis*	X			
276	*Oxypogon guerinii*	X			
277	*Metallura tyrianthina*	X			
278	*Metallura iracunda*		X	Five or fewer occurrence points.	
279	*Metallura williami*	X			

280	*Metallura baroni*		X	Five or fewer occurrence points.
281	*Metallura odomae*		X	Five or fewer occurrence points.
282	*Metallura theresiae*	X		
283	*Metallura eupogon*	X		
284	*Metallura aeneocauda*	X		
285	*Metallura phoebe*	X		
286	*Chalcostigma ruficeps*	X		
287	*Chalcostigma olivaceum*	X		
288	*Chalcostigma stanleyi*	X		
289	*Chalcostigma heteropogon*	X		
290	*Chalcostigma herrani*	X		
291	*Opisthoprora euryptera*	X		
292	*Taphrolesbia griseiventris*		X	Five or fewer occurrence points.
293	*Aglaiocercus kingi*	X		
294	*Aglaiocercus berlepschi*		X	Five or fewer occurrence points.
295	*Aglaiocercus coelestis*	X		
296	*Augustes scutatus*	X		
297	*Augustes lumachella*		X	Five or fewer occurrence points.
298	*Schistes geoffroyi*	X		
299	*Heliothryx barroti*	X		
300	*Heliothryx auritus*	X		
301	*Heliactin bilophus*	X		
302	*Loddigesia mirabilis*		X	Five or fewer occurrence points.
303	*Heliomaster constantii*	X		
304	*Heliomaster longirostris*	X		
305	*Heliomaster squamosus*	X		
306	*Heliomaster furcifer*	X		
307	*Rhodopis vesper*	X		

308	*Thaumastura cora*	X		
309	*Tilmatura dupontii*	X		
310	*Doricha enicura*	X		
311	*Doricha eliza*	X		
312	*Calliphlox amethystina*	X		
313	*Calliphlox evelynae*	X		
314	*Calliphlox bryantae*	X		
315	*Calliphlox mitchellii*	X		
316	*Microstilbon burmeisteri*	X		
317	*Calothorax lucifer*	X		
318	*Calothorax pulcher*	X		
319	*Mellisuga minima*	X		
320	*Mellisuga helenae*	X		
321	*Archilochus colubris*	X		
322	*Archilochus alexandri*	X		
323	*Calypte anna*	X		
324	*Calypte costae*	X		
325	*Atthis heliosa*	X		
326	*Atthis ellioti*	X		
327	*Myrtis fanny*	X		
328	*Eulidia yarrellii*	X		
329	*Myrmia micrurua*	X		
330	*Chaetocercus mulsant*	X		
331	*Chaetocercus bombus*	X		
332	*Chaetocercus heliodor*	X		
333	*Chaetocercus astreans*		X	Five or fewer occurrence points.
334	*Chaetocercus berlepschi*		X	Five or fewer occurrence points.
335	*Chaetocercus jourdanii*	X		

336	*Selasphorus platycercus*	X		
337	*Selasphorus rufus*	X		
338	*Selasphorus sasin*	X		
339	*Selasphorus flammula*	X		
340	*Selasphorus ardens*		X	Five or fewer occurrence points.
341	*Selasphorus scintilla*	X		
342	*Selasphorus calliope*	X		

Appendix 3: Annotated Locality List

Annotated species lists for each locality used in this study, indicating which species were known from the locality and whether they were predicted to occur using neutral models or **M** thresholded models. Species denoted with an ‘m’ are migrants that are not winter residents, with ‘#’ were not modeled (see Appendix 2), and ‘?’ were records of questionable identity or provenance. Species marked with X* are migrants that were excluded from locality lists due to their migratory nature but were subsequently predicted as being winter residents. Taxa are listed in taxonomic order according to Gill & Donsker (2013).

3.1: Municipo Gómez Farías [Municipio Gómez Farías], Tamaulipas, Mexico

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Phaethornis longirostris			X	
Phaethornis pretrei			X	
Phaethornis subochraceus			X	
Phaethornis ruber			X	
Phaeochroa cuvierii			X	
Campylopterus curvipennis	X		X	X
Campylopterus pampa			X	
Campylopterus excellens			X	
Campylopterus hemileucurus			X	
Eupetomena macroura			X	
Colibri thalassinus	X		X	X
Colibri serrirostris			X	
Anthracothorax prevostii	X		X	X
Anthracothorax nigricollis			X	
Abeillia abeillei			X	
Lophornis magnificus			X	
Lophornis chalybeus			X	
Lophornis helenae			X	
Chlorostilbon canivetii	X		X	
Chlorostilbon lucidus			X	
Eupherusa eximia			X	
Cynanthus latirostris	X		X	X
Hylocharis eliciae			X	
Hylocharis sapphirina			X	
Hylocharis cyanus			X	
Hylocharis chrysura			X	
Polytmus guainumbi			X	
Amazilia chionogaster			X	
Amazilia rutile			X	
Amazilia yucatanensis	X		X	X
Amazilia tzacatl	X			
Amazilia versicolor			X	
Amazilia candida			X	X
Amazilia cyanocephala	X		X	X
Amazilia violiceps	X		X	X
Amazilia viridifrons			X	

Amazilia fimbriata			X	
Amazilia beryllina			X	X
Lampornis clemenciae	X			X
Lampornis amethystinus	X			
Lampornis sybillae			X	
Basilinna leucotis	X		X	X
Eugenes fulgens	X		X	X
Heliactin bilophus			X	
Heliomaster constantii			X	
Heliomaster squamosus			X	
Heliomaster furcifer			X	
Tilmatura dupontii			X	
Doricha enichura			X	
Doricha eliza			X	
Calliphlox amethystina			X	
Calothorax lucifer	X			
Archilochus colubris	m		X*	
Archilochus alexandri	m			
Calypte anna				
Atthis heliosa	X		X	
Selasphorus platycercus	X		X	X
Total	**15**	**0**	**54**	**13**

3.2: Crooked Tree Wildlife Sanctuary, Orange Walk, Belize

Scientific Name	**Known pre-2013**	**Post-2013 Confirmations**	**Predicted (no M) ≥25%**	**Predicted (M) ≥25%**
Glaucis hirsutus			X	
Threnetes ruckeri			X	X
Threnetes leucurus			X	
Phaethornis hispidus			X	
Phaethornis longirostris	X		X	X
Phaethornis malaris			X	
Phaethornis philippii			X	
Phaethornis pretrei			X	
Phaethornis subochraceus			X	
Phaethornis ruber			X	
Phaethornis stuarti			X	
Phaethornis striigularis	X		X	X
Phaeochroa cuvierii	X		X	X

Campylopterus pampa	X	X	X
Campylopterus largipennis		X	
Campylopterus hemileucurus		X	X
Eupetomena macroura		X	
Florisuga mellivora	X	X	X
Florisuga fusca		X	
Colibri delphinae		X	X
Anthracothorax viridigula		X	
Anthracothorax prevostii	X	X	X
Anthracothorax nigricollis		X	
Anthracothorax dominicus		X	
Anthracothorax mango		X	
Topaza pella		X	
Eulampis holosericeus		X	
Chlorostilbon mosquitus		X	
Orthorhynchus cristatus		X	
Klais guimeti		X	
Lophornis ornatus		X	
Lophornis magnificus		X	
Lophornis delattrei		X	
Lophornis chalybeus		X	
Lophornis helenae		X	
Discosura langsdorffi		X	
Discosura longicaudus		X	
Trochilus polytmus		X	
Chlorestes notata		X	
Chlorostilbon canivetii	X	X	X
Chlorostilbon mellisugus		X	
Chlorostilbon lucidus		X	
Chlorostilbon ricordii		X	
Chlorostilbon swainsonii		X	
Chlorostilbon maugaeus		X	
Thalurania colombica		X	X
Thalurania furcata		X	
Thalurania watertonii		X	
Hylocharis eliciae			
Hylocharis sapphirina		X	
Hylocharis cyanus		X	
Hylocharis chrysura		X	

Chrysuronia oenone			X	
Polytmus guainumbi			X	
Amazilia rutila	X		X	X
Amazilia yucatanensis	X		X	X
Amazilia tzacatl	X		X	X
Amazilia leucogaster			X	
Amazilia versicolor			X	
Amazilia brevirostris			X	
Amazilia candida	X		X	X
Amazilia cyanocephala	X		X	X
Amazilia fimbriata			X	
Amazilia lactea			X	
Amazilia luciae			X	
Amazilia tobaci			X	
Heliothryx barroti	X		X	X
Heliothryx auritus			X	
Heliomaster longirostris			X	X
Heliomaster furcifer			X	
Doricha eliza			X	
Mellisuga minima			X	
Mellisuga helenae			X	
Archilochus colubris	X		X	X
Total	**14**	**0**	**74**	**19**

3.3: Zamorano University Campus Farms and River, Francisco Morazán, Honduras

Scientific Name	**Known pre-2013**	**Post-2013 Confirmations**	**Predicted (no M) ≥25%**	**Predicted (M) ≥25%**
Glaucis hirsutus			X	
Phaethornis guy			X	
Phaethornis longirostris			X	X
Phaethornis anthophilus			X	
Phaethornis pretrei			X	
Phaethornis augusti			X	
Phaethornis nattereri			X	
Phaethornis striigularis			X	X
Phaethornis griseogularis			X	
Doryfera ludovicae			X	
Campylopterus curvipennis			X	
Campylopterus pampa				

Campylopterus hemileucurus	X	X	X
Campylopterus falcatus		X	
Aphantachroa cirrochloris		X	
Florisuga mellivora	X		X
Colibri delphinae	X	X	X
Colibri thalassinus	X	X	X
Colibri coruscans		X	
Colibri serrirostris		X	
Anthracothorax prevostii	X	X	
Anthracothorax nigricollis		X	
Chrysolampis mosquitus		X	
Klais guimeti		X	X
Abeillia abeillei		X	X
Lophornis magnificus		X	
Lophornis delattrei		X	
Lophornis stictolophus		X	
Lophornis helenae		X	X
Chlorostilbon canivetii	X	X	X
Chlorostilbon mellisugus		X	
Chlorostilbon gibsoni		X	
Chlorostilbon lucidus		X	
Chlorostilbon alice		X	
Eupherusa eximia		X	X
Cynanthus sordidus		X	
Cynanthus latirostris		X	
Cynanthus doubledayi		X	
Thalurania colombica		X	X
Thalurania furcata		X	
Thalurania watertonii		X	
Thalurania glaucopis		X	
Hylocharis eliciae			
Hylocharis sapphirina		X	
Hylocharis cyanus		X	
Hylocharis chrysura		X	
Chrysuronia oenone		X	
Amazilia chionogaster		X	
Amazilia viridicauda		X	
Amazilia rutila	X	X	X
Amazilia tzacatl		X	X

Amazilia amazilia		X	
Amazilia versicolor		X	
Amazilia candida		X	X
Amazilia cyanocephala	X	X	X
Amazilia violiceps		X	
Amazilia viridifrons		X	
Amazilia fimbriata		X	
Amazilia lactea		X	
Amazilia luciae			
Amazilia saucerottii		X	X
Amazilia cyanura	X	X	X
Amazilia beryllina	X	X	X
Amazilia tobaci		X	
Chalybura buffoni		X	
Lampornis clemenciae		X	
Lampornis amethystinus	X	X	X
Lampornis viridipallens		X	X
Lampornis sybillae	X	X	X
Basilinna leucotis	X	X	X
Lamprolaima rhami	X	X	X
Adelomyia melanogenys		X	
Heliodoxa leadbeateri		X	
Eugenes fulgens	X	X	X
Sternoclyta cyanopectus		X	
Coeligena coeligena		X	
Coeligena violifer		X	
Eriocnemis glaucopoides		X	
Haplophaedia assimilis		X	
Ocreatus underwoodii		X	
Chalcostigma ruficeps		X	
Aglaiocercus kingi		X	
Heliothryx barroti			
Heliactin bilophus		X	
Heliomaster constantii	X	X	X
Heliomaster longirostris		X	X
Heliomaster squamosus		X	
Heliomaster furcifer		X	
Tilmatura dupontii	X	X	X
Doricha enichura	X	X	X

Doricha eliza			X	
Calliphlox amethystina			X	
Calothorax lucifer			X	
Calothorax pulcher			X	
Mellisuga minima			X	
Archilochus colubris	X		X	X
Atthis heliosa			X	
Atthis ellioti	X		X	X
Chaetocercus mulsant			X	
Chaetocercus bombus			X	
Chaetocercus jourdanii			X	
Selasphorus platycercus			X	
Total	**20**	**0**	**98**	**31**

3.4: Rancho Naturalista, Cartago, Costa Rica

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Ramphodon naevius			X	
Eutoxeres aquila	X		X	X
Eutoxeres condamini			X	
Glaucis hirsutus			X	
Glaucis aeneus	X		X	X
Threnetes ruckeri	X		X	X
Threnetes leucurus			X	
Phaethornis yaruqui			X	
Phaethornis guy	X		X	X
Phaethornis hispidus			X	
Phaethornis longirostris	X		X	X
Phaethornis superciliosus			X	
Phaethornis malaris			X	
Phaethornis syrmatophorus			X	
Phaethornis koepckeae			X	
Phaethornis philippii			X	
Phaethornis bourcieri			X	
Phaethornis anthophilus			X	
Phaethornis eurynome			X	
Phaethornis pretrei			X	
Phaethornis augusti			X	
Phaethornis ruber			X	

Phaethornis stuarti		X	
Phaethornis atrimentalis		X	
Phaethornis striigularis	X	X	X
Phaethornis griseogularis		X	
Androdon aequatorialis		X	
Doryfera ludovicae	X		X
Doryfera johannae		X	
Phaeochroa cuvierii	X	X	X
Campylopterus curvipennis		X	
Campylopterus excellens		X	
Campylopterus largipennis		X	
Campylopterus hyperythrus		X	
Campylopterus hemileucurus	X	X	X
Campylopterus falcatus		X	
Campylopterus villaviscensio		X	
Aphantochroa cirrochloris		X	
Eupetomena macroura		X	
Florisuga mellivora	X	X	X
Florisuga fusca		X	
Colibri delphinae	X	X	X
Colibri thalassinus	X	X	X
Colibri coruscans		X	
Colibri serrirostris		X	
Anthracothorax prevostii	X	X	X
Anthracothorax nigricollis		X	
Anthracothorax veraguensis	?		
Anthracothorax viridis		X	
Topaza pella		X	
Topaza pyra		X	
Chrysolampis mosquitus		X	
Klais guimeti	X	X	X
Stephanoxis lalandi		X	
Abeillia abeillei		X	
Lophornis magnificus		X	
Lophornis delattrei		X	
Lophornis stictolophus		X	
Lophornis chalybeus		X	
Lophornis pavoninus		X	
Lophornis helenae	X	X	X

Lophornis adorabilis	X	X	
Discosura popelairii		X	
Discosura langsdorffi		X	
Discosura consversii	X	X	X
Discosura longicaudus		X	
Trochilus polytmus		X	
Chlorestes notata		X	
Chlorostilbon canivetii	X		
Chlorostilbon assimilis	X	X	
Chlorostilbon mellisugus		X	
Chlorostilbon melanorhynchus		X	
Chlorostilbon maugaeus		X	
Panterpe insignis	X	X	X
Elvira chionura		X	X
Elvira cupreiceps	X	X	X
Eupherusa eximia	X	X	X
Eupherusa nigriventris	X	X	X
Cyanophaia bicolor		X	
Thalurania colombica	X	X	X
Thalurania furcata		X	
Thalurania glaucopis		X	
Damophila julie		X	
Hylocharis eliciae	X	X	X
Hylocharis sapphirina		X	
Hylocharis cyanus		X	
Chrysuronia oenone		X	
Leucochloris albicollis		X	
Polytmus milleri		X	
Taphrospilus hypostictus		X	
Amazilia viridicauda		X	
Amazilia rutila	X		
Amazilia tzacatl	X	X	X
Amazilia leucogaster		X	
Amazilia versicolor		X	
Amazilia candida		X	
Amazilia cyanocephala		X	
Amazilia fimbriata		X	
Amazilia lactea		X	
Amazilia amabilis	X	X	X

Amazilia decora			
Amazilia rosenbergi		X	
Amazilia saucerottii	X	X	X
Amazilia edward		X	
Amazilia viridigaster		X	
Microchera albocoronata	X	X	X
Chalybura buffoni		X	
Chalybura urochrysia	X	X	X
Lampornis amethystinus		X	
Lampornis viridipallens		X	
Lampornis hemileucus	X	X	X
Lampornis calolaemus	X	X	X
Lampornis cinereicauda	X		
Lamprolaima rhami		X	
Adelomyia melanogenys		X	
Phlogophilus hemileucurus		X	
Clytolaema rubricauda		X	
Heliodoxa xanthogonys		X	
Heliodoxa branickii		X	
Heliodoxa schreibersii		X	
Heliodoxa aurescens		X	
Heliodoxa rubinoides		X	
Heliodoxa jacula	X	X	X
Heliodoxa imperatrix		X	
Heliodoxa leadbeateri		X	
Eugenes fulgens	X	X	X
Sternoclyta cyanopectus		X	
Urochroa bougueri		X	
Boissonneaua flavescens		X	
Boissonneaua jardini		X	
Coeligena coeligena		X	
Coeligena wilsoni		X	
Coeligena torquata		X	
Heliangelus amethysticollis		X	
Heliangelus exortis		X	
Haplophaedia aureliae		X	
Urosticte benjamini		X	
Urosticte ruficrissa		X	
Ocreatus underwoodii		X	

Metallura tyrianthina			X	
Aglaiocercus kingi			X	
Aglaiocercus coelestis			X	
Schistes geoffroyi			X	
Heliothryx barroti	X		X	X
Heliothryx auritus			X	
Heliomaster longirostris	X		X	X
Heliomaster squamosus			X	
Tilmatura dupontii			X	
Doricha enichura			X	
Calliphlox amethystina			X	
Calliphlox bryantae	X		X	X
Calliphlox mitchellii			X	
Mellisuga minima			X	
Archilochus colubris	X		X	
Atthis heliosa			X	
Atthis ellioti			X	
Chaetocercus mulsant			X	
Chaetocercus bombus			X	
Chaetocercus heliodor			X	
Selasphorus flammula	X		X	
Selasphorus scintilla	X		X	X
Total	**42**	**0**	**156**	**36**

3.5: RNA Reinita Cielo Azul [Cerulean Warbler Reserve], Santander, Colombia

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Ramphodon naevius			X	
Eutoxeres aquila	X		X	X
Eutoxeres condamini			X	
Glaucis hirsutus	X		X	X
Threnetes ruckeri			X	X
Threnetes leucurus			X	
Phaethornis yaruqui			X	
Phaethornis guy	X		X	X
Phaethornis hispidus			X	
Phaethornis longirostris	X		X	X
Phaethornis superciliosus			X	
Phaethornis malaris			X	

Phaethornis syrmatophorus				X	
Phaethornis koepckeae				X	
Phaethornis philippii				X	
Phaethornis bourcieri				X	
Phaethornis anthophilus	X			X	X
Phaethornis eurynome				X	
Phaethornis pretrei				X	
Phaethornis augusti				X	X
Phaethornis longuemareus				X	
Phaethornis idaliae				X	
Phaethornis ruber				X	
Phaethornis stuarti				X	
Phaethornis atrimentalis				X	
Phaethornis striigularis	X			X	X
Phaethornis griseogularis				X	X
Doryfera ludovicae	X			X	X
Doryfera johannae				X	
Phaeochroa cuvierii					
Campylopterus curvipennis				X	
Campylopterus pampa				X	
Campylopterus largipennis				X	
Campylopterus hyperythrus				X	
Campylopterus hemileucurus				X	
Campylopterus ensipennis				X	
Campylopterus falcatus	X			X	X
Aphantochroa cirrochloris				X	
Eupetomena macoura				X	
Florisuga mellivora	X			X	X
Florisuga fusca				X	
Colibri delphinae	X			X	X
Colibri thalassinus	X			X	X
Colibri coruscans			X	X	X
Colibri serrirostris				X	
Anthracothorax viridigula				X	
Anthracothorax prevostii					
Anthracothorax nigricollis	X			X	X
Anthracothorax dominicus				X	
Anthracothorax mango				X	
Topaza pella				X	

Topaza pyra			X	
Eulampis holosericeus			X	
Chrysolampis mosquitus		X	X	X
Orthorhynchus cristatus			X	
Klais guimeti			X	X
Stephanoxis lalandi			X	
Abeillia abeillei			X	
Lophornis ornatus			X	
Lophornis magnificus			X	
Lophornis delattrei			X	X
Lophornis stictolophus			X	
Lophornis chalybeus			X	
Lophornis pavoninus			X	
Lophornis helenae			X	
Discosura popelairii				
Discosura langsdorffi			X	
Discosura conversii			X	
Discosura longicaudus			X	
Trochilus polytmus			X	
Chlorestes notata			X	
Chlorostilbon canivetii			X	
Chlorostilbon mellisugus			X	X
Chlorostilbon melanorhynchus			X	
Chlorostilbon gibsoni	X		X	X
Chlorostilbon lucidus			X	
Chlorostilbon ricordii			X	
Chlorostilbon swainsonii			X	
Chlorostilbon maugaeus			X	
Chlorostilbon stenurus		X	X	
Chlorostilbon alice			X	
Chlorostilbon poortmani	X		X	X
Eupherusa eximia			X	
Cyanophaia bicolor			X	
Thalurania colombica	X		X	X
Thalurania furcata			X	
Thalurania watertonii			X	
Thalurania glaucopis			X	
Damophila julie	X		X	X
Lepidopyga goudoti		X	X	X

Hylocharis sapphirina				X	
Hylocharis cyanus				X	
Hylocharis chrysura				X	
Hylocharis grayi				X	
Chrysuronia oenone				X	X
Leucochloris albicollis				X	
Polytmus guainumbi				X	
Polytmus milleri				X	
Taphrospilus hypostictus				X	
Amazilia chionogaster				X	
Amazilia viridicauda				X	
Amazilia tzacatl	X			X	X
Amazilia castaneiventris	#				
Amazilia leucogaster				X	
Amazilia versicolor				X	
Amazilia brevirostris				X	
Amazilia franciae	X			X	X
Amazilia candida				X	
Amazilia cyanocephala				X	
Amazilia fimbriata				X	
Amazilia lactea				X	
Amazilia amabilis			X	X	X
Amazilia luciae				X	
Amazilia saucerottii	X			X	X
Amazilia cyanifrons	X			X	X
Amazilia viridigaster				X	
Amazilia tobaci				X	
Microchera albocoronata				X	
Chalybura buffoni	X			X	X
Lampornis amethystinus				X	
Lampornis viridipallens				X	
Lampornis sybillae				X	
Basilinna leucotis				X	
Lamprolaima rhami				X	
Adelomyia melanogenys	X			X	X
Phlogophilus hemileucurus				X	
Clytolaema rubricauda				X	
Heliodoxa xanthogonys				X	
Heliodoxa branickii				X	

Heliodoxa aurescens				X	
Heliodoxa rubinoides	X			X	X
Heliodoxa jacula	X			X	
Heliodoxa imperatrix				X	
Heliodoxa leadbeateri			X	X	
Eugenes fulgens				X	
Sternoclyta cyanopectus				X	
Urochroa bougueri				X	
Boissonneaua flavescens	X			X	X
Boissonneaua matthewsii				X	
Boissonneaua jardini				X	
Aglaeactis cupripennis					
Lafresnaya lafresnayi					
Coeligena coeligena				X	X
Coeligena wilsoni				X	
Coeligena prunellei	X			X	X
Coeligena torquata	X			X	X
Coeligena bonapartei					
Coeligena helianthea					
Coeligena violifer				X	
Ensifera ensifera				X	X
Pterophanes cyanopterus				X	
Heliangelus amethysticollis				X	X
Heliangelus exortis				X	X
Heliangelus viola				X	
Eriocnemis vestita				X	
Eriocnemis cupreoventris					
Eriocnemis aline				X	
Haplophaedia aureliae				X	X
Haplophaedia assimilis				X	
Ocreatus underwoodii	X			X	X
Lesbia nuna					
Ramphomicron microrhynchum				X	
Metallura tyrianthina				X	X
Chalcostigma ruficeps				X	
Chalcostigma heteropogon					
Aglaiocercus kingi	X			X	X
Aglaiocercus coelestis				X	
Schistes geoffroyi	X			X	X

Heliothryx barroti		X	X	X
Heliothryx auritus			X	
Heliomaster longirostris	X		X	X
Heliomaster squamosus			X	
Tilmatura dupontii			X	
Doricha enicura			X	
Doricha eliza			X	
Calliphlox amethystina			X	
Calliphlox mitchellii			X	
Mellisuga minima			X	
Archilochus colubris			X	
Chaetocercus mulsant		X	X	X
Chaetocercus bombus			X	
Chaetocercus heliodor	X		X	X
Chaetocercus jourdanii			X	
Total	**32**	**8**	**172**	**49**

3.6: Atta Lodge, Potaro-Siparuni, Guyana

Scientific Name	**Known pre-2013**	**Post-2013 Confirmations**	**Predicted (no M) ≥25%**	**Predicted (M) ≥25%**
Glaucis hirsutus	X		X	X
Threnetes ruckeri			X	
Threnetes leucurus	X			
Phaethornis hispidus			X	
Phaethornis longirostris			X	
Phaethornis superciliosus	X		X	X
Phaethornis malaris			X	
Phaethornis philippii			X	
Phaethornis bourcieri			X	X
Phaethornis anthophilus			X	
Phaethornis augusti	X		X	X
Phaethornis rupurumii			X	X
Phaethornis longuemareus	X		X	
Phaethornis ruber	X		X	X
Phaethornis striigularis			X	
Phaethornis griseogularis				
Doryfera johannae				
Phaeochroa cuvierii			X	
Campylopterus largipennis	X		X	X

Campylopterus hyperythrus				
Florisuga mellivora	X		X	X
Colibri delphinae				
Anthracothorax viridigula			X	X
Anthracothorax nigricollis	X		X	X
Avocettula recurvirostris		X	X	X
Topaza pella	X		X	X
Chrysolampis mosquitus			X	X
Lophornis ornatus	X		X	X
Lophornis delattrei			X	
Lophornis chalybeus			X	X
Lophornis pavoninus				
Discosura langsdorffi				
Discosura longicaudus	X		X	X
Chlorestes notata	X		X	X
Chlorostilbon assimilis			X	
Chlorostilbon mellisugus	X		X	X
Chlorostilbon gibsoni			X	
Cyanophaia bicolor			X	
Thalurania colombica			X	
Thalurania furcata	X		X	X
Thalurania watertonii			X	
Damophila julie			X	
Lepidopyga coeruleogularis			X	
Lepidopyga goudoti			X	
Hylocharis sapphirina	X		X	X
Hylocharis cyanus	X		X	X
Polytmus guainumbi		X	X	X
Polytmus theresiae	X		X	X
Amazilia tzacatl			X	
Amazilia leucogaster		X	X	X
Amazilia versicolor			X	X
Amazilia brevirostris	X		X	X
Amazilia fimbriata	X		X	X
Amazilia lactea				
Amazilia amabilis			X	
Amazilia luciae			X	
Amazilia viridigaster			X	
Amazilia tobaci			X	

Chalybura buffoni			X	
Heliodoxa xanthogonys				
Heliothryx auritus	X		X	X
Heliomaster longirostris	X		X	X
Calliphlox amethystina			X	X
Total	**22**	**3**	**54**	**30**

3.7: Tandayapa Bird Lodge, Pichincha, Ecuador

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Ramphodon naevius			X	
Eutoxeres aquila			X	X
Eutoxeres condamini			X	
Glaucis hirsutus			X	
Glaucis aeneus			X	
Threnetes ruckeri			X	X
Threnetes leucurus			X	
Phaethornis yaruqui	X		X	X
Phaethornis longirostris			X	
Phaethornis superciliosus			X	
Phaethornis malaris			X	
Phaethornis syrmatophorus	X		X	X
Phaethornis koepckeae			X	
Phaethornis anthophilus			X	
Phaethornis eurynome			X	
Phaethornis pretrei			X	
Phaethornis augusti			X	
Phaethornis squalidus			X	
Phaethornis ruber			X	
Phaethornis stuarti			X	
Phaethornis atrimentalis			X	
Phaethornis striigularis	X		X	X
Phaethornis griseogularis			X	
Androdon aequatorialis			X	
Doryfera ludovicae	X		X	X
Doryfera johannae			X	
Phaeochroa cuvierii			X	
Campylopterus curvipennis			X	
Campylopterus pampa			X	

Campylopterus excellens		X	
Campylopterus largipennis		X	
Campylopterus hyperythrus		X	
Campylopterus hemileucurus		X	
Campylopterus ensipennis		X	
Campylopterus falcatus		X	
Aphantochroa cirrochloris		X	
Eupetomena macoura		X	
Florisuga mellivora	X	X	X
Florisuga fusca		X	
Colibri delphinae	X	X	X
Colibri thalassinus	X	X	X
Colibri coruscans	X	X	X
Colibri serrirostris		X	
Anthracothorax prevostii		X	
Anthracothorax iridescens	X		
Anthracothorax nigricollis		X	
Anthracothorax dominicus		X	
Topaza pella		X	
Chrysolampis mosquitus		X	
Klais guimeti		X	
Stephanoxis lalandi		X	
Abeillia abeillei		X	
Lophornis ornatus		X	
Lophornis magnificus		X	
Lophornis delattrei		X	
Lophornis stictolophus		X	
Lophornis chalybeus		X	
Lophornis pavoninus		X	
Lophornis helenae		X	
Lophornis adorabilis		X	
Discosura popelairii		X	
Discosura langsdorffi		X	
Discosura consversii	X	X	X
Discosura longicaudus		X	
Trochilus polytmus		X	
Chlorestes notata		X	
Chlorostilbon canivetii		X	
Chlorostilbon assimilis		X	

Chlorostilbon mellisugus		X	
Chlorostilbon melanorhynchus	X	X	X
Chlorostilbon gibsoni		X	
Chlorostilbon lucidus		X	
Chlorostilbon swainsonii		X	
Chlorostilbon stenurus		X	
Chlorostilbon alice		X	
Chlorostilbon poortmani		X	
Panterpe insignis		X	
Elvira chionura		X	
Elvira cupreiceps		X	
Eupherusa eximia		X	
Eupherusa nigriventris		X	
Thalurania colombica	X	X	X
Thalurania furcata		X	
Thalurania watertonii		X	
Thalurania glaucopis		X	
Damophila julie	X	X	
Lepidopyga goudoti		X	
Hylocharis eliciae		X	
Hylocharis sapphirina		X	
Hylocharis cyanus		X	
Hylocharis grayi		X	X
Chrysuronia oenone		X	
Leucochloris albicollis		X	
Polytmus milleri		X	
Taphrospilus hypostictus		X	
Amazilia chionogaster		X	
Amazilia viridicauda		X	
Amazilia rutila		X	
Amazilia tzacatl	X	X	X
Amazilia amazilia		X	
Amazilia versicolor		X	
Amazilia franciae	X	X	X
Amazilia candida		X	
Amazilia cyanocephala		X	
Amazilia viridifrons		X	
Amazilia fimbriata		X	
Amazilia lactea		X	

Amazilia amabilis	X	X	
Amazilia rosenbergi	X	X	
Amazilia saucerottii		X	
Amazilia cyanifrons		X	
Amazilia edward		X	
Amazilia cyanura		X	
Amazilia beryllina		X	
Amazilia viridigaster		X	
Amazilia tobaci		X	
Microchera albocoronata		X	
Chalybura buffoni		X	X
Chalybura urochrysia		X	
Lampornis clemenciae		X	
Lampornis amethystinus		X	
Lampornis viridipallens		X	
Lampornis sybillae		X	
Lampornis hemileucus		X	
Lampornis calolaemus		X	
Lampornis cinereicauda		X	
Basilinna leucotis		X	
Lamprolaima rhami		X	
Adelomyia melanogenys	X	X	X
Phlogophilus hemileucurus		X	
Clytolaema rubricauda		X	
Heliodoxa xanthogonys		X	
Heliodoxa branickii		X	
Heliodoxa aurescens		X	
Heliodoxa rubinoides	X	X	X
Heliodoxa jacula	X	X	X
Heliodoxa imperatrix	X	X	X
Heliodoxa leadbeateri		X	
Eugenes fulgens		X	
Sternoclyta cyanopectus		X	
Urochroa bougueri	X	X	X
Boissonneaua flavescens	X	X	X
Boissonneaua matthewsii		X	X
Boissonneaua jardini	X	X	X
Aglaeactis cupripennis	X	X	
Aglaeactis pamela		X	

Oreotrochilus chimborazo	X		
Lafresnaya lafresnayi	X	X	X
Coeligena coeligena		X	X
Coeligena wilsoni	X	X	X
Coeligena prunellei		X	
Coeligena torquata	X	X	X
Coeligena bonapartei		X	
Coeligena helianthea		X	
Coeligena lutetiae	X	X	X
Coeligena violifer		X	
Coeligena iris		X	
Ensifera ensifera	X	X	X
Pterophanes cyanopterus	X	X	X
Patagona gigas	X	X	
Heliangelus mavors		X	
Heliangelus amethysticollis		X	
Heliangelus strophianus	#		
Heliangelus exortis		X	X
Heliangelus viola		X	
Eriocnemis nigrivestis	#		
Eriocnemis vestita		X	X
Eriocnemis derbyi			
Eriocnemis cupreoventris		X	
Eriocnemis luciani	X	X	X
Eriocnemis mosquera	X		
Eriocnemis aline		X	
Haplophaedia aureliae		X	X
Haplophaedia assimilis		X	
Haplophaedia lugens	#		
Urosticte benjamini	X	X	X
Urosticte ruficrissa		X	
Ocreatus underwoodii	X	X	X
Lesbia victoriae	X	X	X
Lesbia nuna	X	X	X
Ramphomicron microrhynchum	X	X	X
Metallura tyrianthina	X	X	X
Metallura williami			
Metallura theresiae		X	
Metallura eupogon		X	

Chalcostigma ruficeps			X	
Chalcostigma stanleyi				
Chalcostigma heteropogon			X	
Chalcostigma herrani	X			
Opisthoprora euryptera				
Aglaiocercus kingi	X		X	X
Aglaiocercus coelestis	X		X	X
Schistes geoffroyi	X		X	X
Heliothryx barroti	X		X	X
Heliothryx auritus			X	
Heliactin bilophus			X	
Heliomaster longirostris	X		X	X
Heliomaster squamosus			X	
Tilmatura dupontii			X	
Doricha enicura			X	
Doricha eliza			X	
Calliphlox amethystina			X	
Calliphlox bryantae			X	
Calliphlox mitchellii	X		X	X
Calothorax lucifer			X	
Mellisuga minima			X	
Archilochus colubris			X	
Atthis heliosa			X	
Atthis ellioti			X	
Myrtis fanny	X		X	X
Chaetocercus mulsant	X		X	X
Chaetocercus bombus	X		X	X
Chaetocercus heliodor			X	X
Chaetocercus jourdanii			X	
Selasphorus platycercus			X	
Selasphorus flammula			X	
Selasphorus scintilla			X	
Total	**51**	**0**	**207**	**52**

3.8: Sacha Lodge, Sucumbíos, Ecuador

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Eutoxeres aquila			X	X
Eutoxeres condamini	X		X	X

Glaucis hirsutus	X	X	X
Glaucis aeneus		X	
Threnetes ruckeri		X	
Threnetes leucurus	X	X	X
Phaethornis yaruqui		X	
Phaethornis guy		X	
Phaethornis hispidus	X	X	X
Phaethornis longirostris		X	
Phaethornis malaris	X	X	X
Phaethornis philippii		X	
Phaethornis bourcieri	X	X	X
Phaethornis ruber	X	X	X
Phaethornis stuarti		X	
Phaethornis atrimentalis	X	X	X
Phaethornis striigularis		X	
Phaethornis griseogularis		X	X
Androdon aequatorialis		X	
Doryfera johannae		X	X
Campylopterus largipennis	X	X	X
Campylopterus hyperythrus		X	
Campylopterus villaviscensio		X	
Florisuga mellivora	X	X	X
Colibri delphinae		X	X
Colibri coruscans	?		
Anthracothorax prevostii		X	
Anthracothorax nigricollis	X	X	X
Avocettula recurvirostris			X
Topaza pyra		X	X
Orthorhynchus cristatus		X	
Klais guimeti		X	X
Lophornis delattrei		X	
Lophornis stictolophus		X	X
Lophornis chalybeus		X	X
Lophornis pavoninus		X	
Lophornis helenae		X	
Discosura langsdorffi		X	
Discosura consversii		X	
Discosura longicaudus		X	
Chlorestes notata	X	X	X

Chlorostilbon mellisugus	X		X	X
Cyanophaia bicolor			X	
Thalurania colombica			X	
Thalurania furcata	X		X	X
Hylocharis sapphirina	X		X	X
Hylocharis cyanus			X	
Chrysuronia oenone	X		X	X
Polytmus theresiae			X	
Leucippus chlorocercus	X		X	
Amazilia tzacatl			X	
Amazilia leucogaster			X	
Amazilia versicolor			X	X
Amazilia fimbriata	X		X	X
Amazilia lactea			X	X
Amazilia amabilis			X	
Amazilia rosenbergi			X	
Microchera albocoronata			X	
Chalybura urochrysia			X	
Phlogophilus hemileucurus			X	X
Helidoxa xanthogonys			X	
Heliodoxa branickii			X	
Heliodoxa schreibersii	X		X	X
Heliodoxa aurescens	X		X	X
Heliothryx barroti			X	
Heliothryx auritus	X		X	X
Heliomaster longirostris	X		X	X
Calliphlox amethystina	X		X	X
Total	**24**	**0**	**66**	**35**

3.9: Copalinga Lodge, Zamora-Chinchipe, Ecuador

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Eutoxeres aquila	X		X	X
Eutoxeres condamini	X		X	X
Glaucis hirsutus			X	X
Threnetes ruckeri			X	
Threnetes leucurus	X		X	X
Phaethornis yaruqui			X	
Phaethornis guy	X		X	X

Phaethornis hispidus				X
Phaethornis longirostris			X	
Phaethornis malaris	X		X	X
Phaethornis syrmatophorus	X		X	X
Phaethornis koepckeae			X	
Phaethornis bourcieri				
Phaethornis anthophilus			X	
Phaethornis eurynome			X	
Phaethornis pretrei			X	
Phaethornis augusti			X	
Phaethornis ruber			X	X
Phaethornis stuarti			X	
Phaethornis atrimentalis			X	X
Phaethornis striigularis			X	
Phaethornis griseogularis	X		X	X
Doryfera ludovicae	X		X	X
Doryfera johannae	X		X	X
Campylopterus largipennis		X	X	X
Campylopterus hyperythrus			X	
Campylopterus ensipennis			X	
Campylopterus falcatus			X	
Campylopterus villaviscensio	X		X	X
Aphantochroa cirrochloris			X	
Eupetomena macoura			X	
Florisuga mellivora		X	X	X
Florisuga fusca			X	
Colibri delphinae	X		X	X
Colibri thalassinus	X		X	X
Colibri coruscans	X		X	X
Colibri serrirostris			X	
Anthracothorax prevostii			X	
Anthracothorax nigricollis			X	X
Anthracothorax dominicus			X	
Anthracothorax mango			X	
Topaza pella			X	
Topaza pyra			X	X
Chrysolampis mosquitus			X	
Orthorhynchus cristatus			X	
Klais guimeti	X		X	X

Stephanoxis lalandi			X	
Abeillia abeillei			X	
Lophornis ornatus			X	
Lophornis magnificus			X	
Lophornis delattrei			X	
Lophornis stictolophus	X		X	X
Lophornis chalybeus			X	X
Lophornis pavoninus			X	
Lophornis helenae			X	
Discosura popelairii	X		X	X
Discosura langsdorffi		X	X	X
Discosura longicaudus			X	
Trochilus polytmus			X	
Chlorestes notata			X	X
Chlorostilbon mellisugus	X		X	X
Chlorostilbon melanorhynchus			X	
Chlorostilbon gibsoni			X	
Chlorostilbon lucidus			X	
Chlorostilbon swainsonii			X	
Chlorostilbon maugaeus			X	
Chlorostilbon stenurus			X	
Chlorostilbon alice			X	
Chlorostilbon poortmani			X	
Eupherusa eximia			X	
Cyanophaia bicolor			X	
Thalurania colombica			X	
Thalurania furcata	X		X	X
Thalurania glaucopis			X	
Damophila julie			X	
Lepidopyga goudoti			X	
Hylocharis sapphirina			X	X
Hylocharis cyanus			X	X
Hylocharis grayi			X	
Chrysuronia oenone	X		X	X
Leucochloris albicollis			X	
Polytmus milleri			X	
Leucippus taczanowskii			X	
Taphrospilus hypostictus	X		X	X
Amazilia chionogaster			X	

Amazilia viridicauda				X	
Amazilia tzacatl				X	
Amazilia amazilia	X				
Amazilia leucogaster				X	
Amazilia versicolor				X	X
Amazilia franciae	X			X	X
Amazilia candida				X	
Amazilia cyanocephala				X	
Amazilia fimbriata	X			X	X
Amazilia lactea				X	X
Amazilia saucerottii				X	
Amazilia cyanifrons				X	
Amazilia viridigaster				X	
Amazilia tobaci				X	
Microchera albocoronata				X	
Chalybura buffoni				X	
Lampornis sybillae				X	
Lamprolaima rhami				X	
Adelomyia melanogenys	X			X	X
Phlogophilus hemileucurus	X			X	X
Heliodoxa xanthogonys				X	
Heliodoxa branickii				X	
Heliodoxa schreibersii	X			X	X
Heliodoxa aurescens				X	X
Heliodoxa rubinoides			X	X	X
Heliodoxa imperatrix				X	
Heliodoxa leadbeateri	X			X	X
Eugenes fulgens				X	
Sternoclyta cyanopectus				X	
Urochroa bougueri				X	X
Boissonneaua flavescens				X	
Boissonneaua matthewsii	X			X	X
Boissonneaua jardini				X	
Aglaeactis cupripennis				X	X
Lafresnaya lafresnayi				X	X
Coeligena coeligena	X			X	X
Coeligena wilsoni				X	
Coeligena prunellei				X	
Coeligena torquata	X			X	X

Coeligena bonapartei			X	
Coeligena helianthea			X	
Coeligena lutetiae	X		X	X
Coeligena violifer			X	
Coeligena iris			X	X
Ensifera ensifera			X	X
Pterophanes cyanopterus			X	X
Patagona gigas				
Heliangelus mavors			X	
Heliangelus amethysticollis	X		X	X
Heliangelus exortis			X	X
Heliangelus micraster	#			
Heliangelus viola			X	X
Heliangelus regalis			X	X
Eriocnemis vestita	X		X	X
Eriocnemis derbyi			X	
Eriocnemis cupreoventris			X	
Eriocnemis luciani			X	X
Eriocnemis aline			X	X
Haplophaedia aureliae	X		X	X
Haplophaedia assimilis			X	
Urosticte ruficrissa		X	X	X
Ocreatus underwoodii	X		X	X
Lesbia victoriae			X	X
Lesbia nuna			X	X
Ramphomicron microrhynchum			X	X
Metallura tyrianthina	X		X	X
Metallura williami			X	X
Metallura theresiae			X	
Metallura eupogon			X	
Chalcostigma ruficeps	X		X	X
Chalcostigma stanleyi				
Chalcostigma herrani			X	X
Opisthoprora euryptera			X	X
Aglaiocercus kingi	X		X	X
Aglaiocercus coelestis			X	
Schistes geoffroyi	X		X	X
Heliothryx barroti			X	
Heliothryx auritus	X		X	X

Heliomaster longirostris			X	X
Heliomaster squamosus			X	
Doricha enicura			X	
Calliphlox amethystina	X		X	X
Calliphlox mitchellii			X	
Mellisuga minima			X	
Archilochus colubris			X	
Myrtis fanny			X	X
Chaetocercus mulsant	X		X	X
Chaetocercus bombus	X		X	X
Chaetocercus heliodor			X	
Chaetocercus jourdanii			X	
Total	**43**	**5**	**169**	**79**

3.10: Rio Cristalino [Alta Floresta/Cristalino Lodge Area], Mato Grosso, Brazil

Scientific Name	**Known pre-2013**	**Post-2013 Confirmations**	**Predicted (no M) ≥25%**	**Predicted (M) ≥25%**
Glaucis hirsutus	X		X	X
Threnetes ruckeri			X	
Threnetes leucurus	X			
Phaethornis yaruqui			X	
Phaethornis hispidus	X			
Phaethornis longirostris			X	
Phaethornis superciliosus	X			
Phaethornis malaris	?			
Phaethornis philippii			X	
Phaethornis bourcieri	X			
Phaethornis anthophilus			X	
Phaethornis pretrei	?			
Phaethornis augusti			X	
Phaethornis nattereri			X	
Phaethornis ruber	X		X	
Phaethornis aethopyga	#			
Phaethornis striigularis			X	
Phaethornis griseogularis			X	
Phaeochroa cuvierii			X	
Campylopterus largipennis	X			
Campylopterus rufus			X	
Campylopterus hyperythrus			X	

Campylopterus hemileucurus		X	
Florisuga mellivora	X	X	
Anthracothorax prevostii		X	
Anthracothorax nigricollis	X	X	X
Anthracothorax iridescens		X	
Anthracothorax veraguensis		X	
Avocettula recurvirostris	X	X	
Topaza pella	X		
Chrysolampis mosquitus	X	X	X
Klais guimeti		X	
Lophornis magnificus			X
Lophornis delattrei		X	
Lophornis chalybeus	X	X	X
Lophornis pavoninus		X	
Discosura langsdorffi	X	X	X
Chlorestes notata	?		
Chlorostilbon canivetii		X	
Chlorostilbon assimilis		X	
Chlorostilbon lucidus	?		
Eupherusa cyanophrys		X	
Thalurania colombica		X	
Thalurania furcata	X	X	X
Thalurania watertonii		X	
Damophila julie		X	
Lepidopyga coeruleogularis		X	
Hylocharis eliciae		X	
Hylocharis sapphirina	X	X	
Hylocharis cyanus	X	X	X
Polytmus milleri		X	
Polytmus theresiae	X		
Amazilia tzacatl		X	
Amazilia versicolor	X	X	X
Amazilia viridifrons		X	
Amazilia wagneri		X	
Amazilia fimbriata	X		
Amazilia lactea			
Amazilia amabilis		X	
Amazilia saucerottii		X	
Amazilia edward		X	

Amazilia cyanura			X	
Chalybura buffoni			X	
Heliodoxa branickii			X	
Heliodoxa aurescens	X			
Augastes scutatus			X	
Heliothryx barroti			X	
Heliothryx auritus	X		X	
Heliactin bilophus	?		X	
Heliomaster longirostris	X		X	X
Doricha eliza			X	
Calliphlox amethystina	X		X	X
Lophornis helenae			X	
Total	**24**	**0**	**57**	**11**

3.11: Cock-of-the-Rock Lodge, Cuzco, Peru

Scientific Name	**Known pre-2013**	**Post-2013 Confirmations**	**Predicted (no M) ≥25%**	**Predicted (M) ≥25%**
Ramphodon naevius			X	
Eutoxeres aquila			X	
Eutoxeres condamini	X		X	X
Glaucis hirsutus			X	X
Glaucis aeneus			X	
Threnetes ruckeri			X	
Threnetes leucurus			X	X
Phaethornis yaruqui			X	
Phaethornis guy	X		X	X
Phaethornis hispidus	X		X	X
Phaethornis longirostris			X	
Phaethornis superciliosus			X	
Phaethornis malaris	X		X	X
Phaethornis koepckeae	X		X	X
Phaethornis philippii				
Phaethornis bourcieri			X	
Phaethornis anthophilus			X	
Phaethornis eurynome			X	
Phaethornis pretrei			X	X
Phaethornis augusti			X	
Phaethornis ruber	X		X	X
Phaethornis stuarti	X		X	X

Phaethornis atrimentalis			X	
Phaethornis striigularis			X	
Phaethornis griseogularis			X	
Androdon aequatorialis			X	
Doryfera ludovicae	X		X	X
Doryfera johannae		X	X	X
Phaeochroa cuvierii			X	
Campylopterus curvipennis			X	
Campylopterus excellens			X	
Campylopterus largipennis	X		X	X
Campylopterus hyperythrus			X	
Campylopterus hemileucurus			X	
Campylopterus falcatus			X	
Aphantochroa cirrochloris			X	
Eupetomena macroura			X	X
Florisuga mellivora	X		X	X
Florisuga fusca			X	
Colibri delphinae			X	X
Colibri thalassinus	X		X	X
Colibri coruscans	X		X	X
Colibri serrirostris			X	X
Anthracothorax prevostii			X	
Anthracothorax nigricollis	X		X	X
Topaza pella			X	
Chrysolampis mosquitus			X	
Klais guimeti	X		X	X
Abeillia abeillei			X	
Lophornis ornatus			X	
Lophornis magnificus			X	
Lophornis delattrei	X		X	X
Lophornis stictolophus			X	
Lophornis chalybeus			X	X
Lophornis pavoninus			X	
Lophornis helenae			X	
Discosura popelairii	X		X	X
Discosura langsdorffi			X	X
Discosura consversii			X	
Discosura longicaudus			X	
Chlorestes notata	X		X	X

Chlorostilbon canivetii				X	
Chlorostilbon mellisugus	X			X	X
Chlorostilbon melanorhynchus				X	
Chlorostilbon gibsoni				X	
Chlorostilbon lucidus				X	
Chlorostilbon maugaeus				X	
Chlorostilbon stenurus				X	
Chlorostilbon poortmani				X	
Elvira cupreiceps				X	
Eupherusa eximia				X	
Eupherusa nigriventris				X	
Cynanthus latirostris				X	
Cyanophaia bicolor				X	
Thalurania colombica				X	
Thalurania furcata	X			X	X
Thalurania glaucopis				X	
Damophila julie				X	
Lepidopyga goudoti				X	
Hylocharis eliciae				X	
Hylocharis sapphirina				X	X
Hylocharis cyanus			X	X	X
Hylocharis chrysura					
Chrysuronia oenone	X			X	X
Polytmus milleri				X	
Polytmus theresiae					X
Leucippus taczanowskii				X	
Taphrospilus hypostictus	X			X	X
Amazilia chionogaster	X			X	X
Amazilia viridicauda	X			X	X
Amazilia tzacatl				X	
Amazilia amazilia				X	
Amazilia versicolor				X	X
Amazilia candida				X	
Amazilia cyanocephala				X	
Amazilia wagneri				X	
Amazilia fimbriata				X	X
Amazilia lactea	X			X	X
Amazilia amabilis				X	
Amazilia rosenbergi				X	

Amazilia saucerottii		X	
Amazilia cyanura		X	
Amazilia viridigaster		X	
Amazilia tobaci		X	
Microchera albocoronata		X	
Chalybura buffoni		X	
Chalybura urochrysia		X	
Lampornis clemenciae		X	
Lampornis amethystinus		X	
Lampornis viridipallens		X	
Lampornis sybillae		X	
Lampornis calolaemus		X	
Basilinna leucotis		X	
Lamprolaima rhami		X	
Adelomyia melanogenys	X	X	X
Phlogophilus harterti	#		
Clytolaema rubricauda		X	
Heliodoxa xanthogonys		X	
Heliodoxa branickii	X	X	X
Heliodoxa schreibersii	X		X
Heliodoxa aurescens	X	X	X
Heliodoxa rubinoides	X	X	X
Heliodoxa jacula		X	
Heliodoxa leadbeateri	X	X	X
Eugenes fulgens		X	
Sternoclyta cyanopectus		X	
Boissonneaua matthewsii	X	X	X
Boissonneaua jardini		X	
Aglaeactis cupripennis	X	X	X
Aglaeactis castelnaudii	X		
Aglaeactis pamela		X	
Oreotrochilus estella	X	X	X
Oreotrochilus leucopleurus		X	
Oreotrochilus adela		X	
Lafresnaya lafresnayi	X	X	X
Coeligena coeligena	X	X	X
Coeligena prunellei		X	
Coeligena torquata	X	X	X
Coeligena violifer	X	X	X

Coeligena iris		X	
Ensifera ensifera	X	X	X
Pterophanes cyanopterus	X	X	X
Patagona gigas	X	X	X
Sephanoides sephanoides		X	
Heliangelus mavors		X	
Heliangelus amethysticollis	X	X	X
Eriocnemis luciani	X	X	X
Eriocnemis glaucopoides		X	
Eriocnemis aline		X	
Haplophaedia aureliae	X		X
Haplophaedia assimilis		X	
Ocreatus underwoodii	X	X	X
Lesbia victoriae	X	X	X
Lesbia nuna	X	X	X
Sappho sparganurus		X	X
Polyonymus caroli		X	X
Ramphomicron microrhynchum	X	X	X
Oreonympha nobilis	X		X
Metallura tyrianthina	X	X	X
Metallura theresiae		X	
Metallura eupogon		X	
Metallura aeneocauda	X	X	X
Metallura phoebe		X	
Chalcostigma ruficeps	X	X	X
Chalcostigma olivaceum			X
Chalcostigma stanleyi	X	X	
Aglaiocercus kingi	X	X	X
Schistes geoffroyi	X	X	X
Heliothryx barroti		X	
Heliothryx auritus	X	X	X
Heliomaster longirostris		X	X
Heliomaster squamosus		X	
Heliomaster furcifer			
Timatura dupontii		X	
Doricha enicura		X	
Doricha eliza		X	
Calliphlox amethystina	X	X	X
Calliphlox mitchellii		X	

Microstilbon burmeisteri			X	
Calothorax lucifer			X	
Mellisuga minima			X	
Archilochus colubris			X	
Atthis heliosa			X	
Atthis ellioti			X	
Myrtis fanny			X	
Chaetocercus mulsant	X		X	X
Chaetocercus bombus			X	
Chaetocercus jourdanii			X	
Selasphorus platycercus			X	
Selasphorus rufus			X	
Selasphorus sasin			X	
Total	**58**	**2**	**179**	**74**

3.12: Curupira Lodge (Serra das Araras), Mato Grosso, Brazil

Scientific Name	Known pre-2013	Post-2013 Confirmations	Predicted (no M) ≥25%	Predicted (M) ≥25%
Glaucis hirsutus		X	X	X
Threnetes ruckeri			X	
Phaethornis hispidus			X	X
Phaethornis longirostris			X	
Phaethornis malaris			X	X
Phaethornis philippii			X	
Phaethornis pretrei	X		X	X
Phaethornis augusti			X	
Phaethornis subochraceus			X	X
Phaethornis nattereri	X		X	X
Phaethornis ruber	X		X	X
Phaethornis striigularis			X	
Phaethornis griseogularis			X	
Phaeochroa cuvierii			X	
Campylopterus pampa			X	
Campylopterus largipennis			X	X
Campylopterus hemileucurus			X	
Aphantochroa cirrochloris			X	
Eupetomena macroura	X		X	X
Florisuga mellivora			X	X
Colibri delphinae			X	X

Colibri serrirostris			X	X
Anthracothorax prevostii			X	
Anthracothorax nigricollis		X	X	X
Anthracothorax dominicus			X	
Chrysolampis mosquitus			X	X
Klais guimeti			X	
Lophornis magnificus			X	
Lophornis delattrei			X	
Lophornis chalybeus			X	X
Lophornis helenae			X	
Discosura langsdorffi			X	X
Chlorestes notata			X	X
Chlorostilbon canivetii			X	
Chlorostilbon mellisugus			X	X
Chlorostilbon lucidus	X		X	X
Chlorostilbon ricordii			X	
Chlorostilbon maugaeus			X	
Eupherusa eximia			X	
Thalurania colombica			X	
Thalurania furcata	X		X	X
Thalurania watertonii			X	
Thalurania glaucopis			X	
Hylocharis sapphirina			X	X
Hylocharis cyanus			X	X
Hylocharis chrysura			X	X
Chrysuronia oenone			X	
Polytmus guainumbi			X	X
Amazilia viridicauda			X	
Amazilia rutila			X	
Amazilia yucatanensis			X	
Amazilia tzacatl			X	
Amazilia leucogaster			X	
Amazilia versicolor		X	X	X
Amazilia candida			X	
Amazilia cyanocephala			X	
Amazilia fimbriata	X		X	X
Amazilia lactea			X	X
Amazilia luciae			X	
Amazilia cyanura			X	

Amazilia tobaci			X	
Lampornis sybillae			X	
Heliothryx barroti			X	
Heliothryx auritus			X	X
Heliactin bilophus			X	X
Heliomaster longirostris	X		X	X
Heliomaster squamosus			X	
Heliomaster furcifer			X	X
Tilmatura dupontii			X	
Doricha eliza			X	
Calliphlox amethystina		X	X	X
Mellisuga minima			X	
Mellisuga helenae			X	
Total	**8**	**4**	**73**	**32**

3.13: Serra dos Tucanos Lodge, Rio de Janeiro, Brazil

Scientific Name	**Known pre-2013**	**Post-2013 Confirmations**	**Predicted (no M) ≥25%**	**Predicted (M) ≥25%**
Ramphodon naevius	X		X	
Glaucis hirsutus	X			X
Phaethornis guy			X	
Phaethornis longirostris			X	
Phaethornis malaris			X	X
Phaethornis eurynome	X		X	X
Phaethornis pretrei	X		X	X
Phaethornis augusti			X	
Phaethornis squalidus	X		X	X
Phaethornis ruber	X		X	X
Phaethornis stuarti			X	
Phaethornis striigularis			X	
Phaethornis griseogularis			X	
Campylopterus curvipennis			X	
Campylopterus pampa			X	
Campylopterus excellens			X	
Campylopterus largipennis	X		X	X
Campylopterus hemileucurus			X	
Campylopterus falcatus			X	
Aphantochroa cirrhochloris	X		X	X
Eupetomena macroura	X		X	X

Florisuga fusca	X	X	X
Colibri delphinae		X	X
Colibri thalassinus		X	
Colibri coruscans		X	
Colibri serrirostris	X	X	X
Anthracothorax nigricollis	X	X	X
Anthracothorax dominicus		X	
Chrysolampis mosquitus			X
Klais guimeti		X	
Stephanoxis lalandi	X	X	X
Abeillia abeillei		X	
Lophornis magnificus	X	X	X
Lophornis delattrei		X	
Lophornis chalybeus		X	X
Lophornis helenae		X	
Discosura langsdorffi			
Discosura longicaudus			X
Trochilus polytmus		X	
Chlorestes notata			
Chlorostilbon canivetii		X	
Chlorostilbon lucidus	X	X	X
Chlorostilbon swainsonii		X	
Eupherusa eximia		X	
Thalurania colombica		X	
Thalurania furcata	X	X	X
Thalurania glaucopis	X	X	X
Hylocharis sapphirina		X	X
Hylocharis cyanus	X	X	X
Hylocharis chrysura		X	
Chrysuronia oenone		X	
Leucochloris albicollis	X	X	X
Polytmus guainumbi		X	X
Taphrospilus hypostictus		X	
Amazilia chionogaster		X	
Amazilia viridicauda		X	
Amazilia yucatanensis		X	
Amazilia tzacatl		X	
Amazilia leucogaster		X	X
Amazilia versicolor	X	X	X

Amazilia candida			X	
Amazilia cyanocephala			X	
Amazilia fimbriata	X		X	X
Amazilia lactea	X		X	X
Amazilia luciae			X	
Amazilia cyanura			X	
Amazilia beryllina			X	
Amazilia viridigaster			X	
Lampornis clemenciae			X	
Lampornis amethystinus			X	
Lampornis viridipallens			X	
Lampornis sybillae			X	
Basilinna leucotis			X	
Lamprolaima rhami			X	
Adelomyia melanogenys			X	
Clytolaema rubricauda	X		X	X
Heliodoxa xanthogonys			X	
Heliodoxa leadbeateri			X	
Eugenes fulgens			X	
Coeligena coeligena			X	
Haplophaedia assimilis			X	
Ocreatus underwoodii			X	
Aglaiocercus kingi			X	
Heliothryx auritus	X		X	X
Heliactin bilophus			X	X
Heliomaster squamosus			X	X
Heliomaster furcifer			X	
Timatura dupontii			X	
Doricha enicura			X	
Doricha eliza			X	
Calliphlox amethystina	X		X	X
Mellisuga minima			X	
Archilochus colubris			X	
Atthis heliosa			X	
Atthis ellioti			X	
Chaetocercus jourdanii			X	
Selasphorus platycercus			X	
Total	**25**	**0**	**92**	**34**